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REPORT OF THE SUPERINTENDENT

OF THE

U. S. COAST AND GEODETIC SURVEY

SHOWING

THE PROGRESS OF THE WORK

DURING THE

FISCAL YEAR ENDING WITH

JUNE, 1886.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1887.

LETTER

FROM

THE SECRETARY OF THE TREASURY,

TRANSMITTING THE

Report of the Superintendent of the Coast and Geodetic Survey for the fiscal year ended June 30, 1886.

DECEMBER 16, 1886.—Laid on the table and ordered to be printed.

TREASURY DEPARTMENT, *December* 15, 1886.

SIR: In compliance with the requirements of section 4690, Revised Statutes, I have the honor to transmit herewith, for the information of Congress, a report addressed to this Department by F. M. Thorn, Superintendent of the Coast and Geodetic Survey, showing the progress made in that work during the fiscal year ended June 30, 1886, and accompanied by charts illustrating the general advance in the operations of the Survey up to that date.

Respectfully yours,

D. MANNING,
Secretary.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

ABSTRACT OF CONTENTS OF REPORT.

TITLES OF APPENDICES.

ALPHABETICAL INDEX.

A.

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ERRATA.

In Coast and Geodetic Survey Report for 1885.

Page 14, fifth line from bottom, insert missing letters in *including*.
Page 24, ninth line from top, for *Oan Orden* read *Van Orden*.
Page 27, sixth line from bottom, for *resurvrg* read *resurvey*.
Page 96, twenty-second line from top, for *of* read *at*.
Page 310, line 1, for **231.8** read **27.5**.
Page 358, line 16, for **833.0** read **883.0**.
Page 366, line 3 from bottom, for **1243.2** read **1551.7**.
Page 415, line 2 from bottom, for *Simmons* read *Simmons* **2**.
Page 424, line 10, for **1709.5** read **1609.5**.
Page 425, line 16, for **3404.1** read **3104.1**.
Page 469, eighth line from bottom, for *kilograms* put *kilometers*.
Page 472, seventeenth line from top, for record *of* read record *at*.
Page 475, twenty-first line from top, for *from* read *for*.
Page 476, ninth line from top, *dele* △.
Page 476, nineteenth line from top, for cBP put CBP.
Page 476, twentieth line from top, for cAP′ put CAP′.
Page 476, twenty-first line from top, for PcB put PCB.
Page 485, fourth line from top, for *Dart* put *Dash*.

ERRATA.

In Coast and Geodetic Survey Report for 1886.

Page vii, last line, for *433* put *432*.
Page viii, last line, for *433* put *432*.
Page 34, line 16 from bottom, for *topographial* put *topographical*.
Page 34, line 16 from bottom, *dele c* at end of line.
Page 69, line 3 from top, for *sight* put *site*.
Page 70, line 19 from top, for *No. 12* put *No. 7*.
Page 105, line 10 from bottom, for *14261* put *8701*.
Page 105, line 10 from bottom, last column of table, for *113841* put *108281*.
Page 106, line 14 from bottom, last column of table, for *291* put *284*.
Page 178, line 5 from top, for *Bartholomè* put *Bartolomè*.

REPORT.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, December 14, 1886.

SIR: In submitting herewith, in accordance with law and with the regulations of the Treasury Department, the report of progress made in the work of the Coast and Geodetic Survey for the fiscal year ending June 30, 1886, I would ask the attention of the Department to a few considerations bearing upon the development which the work has received, and the scale upon which it should be carried to completion.

(1) From 1844, when Professor Bache entered actively upon his duties as Superintendent of the Survey, till his death, in 1867, the work was confined entirely to the seaboard States. Voluntary testimony to its high scientific character, valuable practical results, and the remarkable economy with which it was conducted was repeatedly given during this period by the best authorities at home and abroad.

(2) When the eminent geometer, Peirce, succeeded Bache in the Superintendency, the need of a system of checks for the extended triangulations along the Atlantic and Pacific coasts by a transcontinental triangulation became more fully recognized. It was perceived also that this necessary connection between geodetic operations on opposite sides of the continent would involve the determination of geographical positions in a number of States of the interior, and the desire that these States as well as those of the seaboard should share in the advantages derived from the Survey led to the adoption of the proviso contained in the act of March 3, 1871, that the triangulation for this geodetic connection should determine points in each State of the Union which should make the requisite provision for its own topographical and geological surveys.

(3) That this development of the work of the Survey was regarded as of great advantage in giving to the States interested a means of making trustworthy State maps, is shown by the fact that within eight years from the passage of the act the Governors of fourteen States had applied for aid in making State surveys in accordance with its provisions.

(4) It is submitted therefore that the form which the work of the Coast and Geodetic Survey has of late years assumed is one that is the natural outgrowth of the needs of the country, and of the increased and increasing demands, not only for accurate charts of the seaboard, but also for data upon which the several States can base accurate maps of their entire territory.

(5) And that as the Survey has a corps of officers trained by long experience to execute its work in the most thorough and economical manner, it would be in accordance with the dictates of a sound economy that appropriations should be granted by Congress sufficient in amount to push forward the work to completion at an early date, and to employ to the best advantage the professional skill now at the service of the Government.

It was in pursuance of these views that an increase in the amount appropriated for the field-work of the Survey was asked for the service of the present fiscal year. The estimates prepared on this basis met the approval of the Department. A similar increase is asked for the fiscal year 1887-1888. The reasons for this increase which have been heretofore urged, and which are again stated in the Explanation of Estimates, will be found to be fully in accord with the desire of

Congress as expressed in its resolution for the appointment of a Joint Commission to consider the organizations of the scientific bureaus with the view to secure greater efficiency and economy of administration in the public service.

Part I of this Report includes general summaries of progress in field and office work, and presents brief statements of discoveries and developments made, and of special scientific work accomplished, during the past fiscal year. It concludes with an explanation of the estimates for the fiscal year 1887–1888 and a detailed statement of those estimates.

Part II contains accounts of work done afloat and ashore, compiled from the reports of the chiefs of field parties, and closes with a summary of the operations of the Office during the fiscal year.

Part III comprises the appendices which relate to the distribution of the field parties, to the statistics of the work, and to information furnished from the Office; these are followed by the annual reports of the Assistant in charge of the Office and the Hydrographic Inspector, and by papers which present some of the more noteworthy methods and results of the Survey.

The two maps of general progress (sketches Nos. 1 and 2), one for the eastern part of the United States, the other for the western, show by symbols the advance made in the several operations of the Survey up to the close of the fiscal year. On a separate map is shown the progress of the work in Alaska.

PART I.

It will appear from an examination of this Report, and of the tabular statement given in Appendix No. 1, which shows the distribution of the field parties and the nature of their operations afloat and ashore, that every branch of the Survey was in active prosecution during the fiscal year.

While the geodetic work in the interior was well advanced, due attention was paid to immediate and pressing demands for resurveys of important harbors and high ways of commerce, and special care was taken to give wide publicity to discoveries of dangers to navigation by the publication of Notices to Mariners. Fifteen of these notices were issued during the year, four of which related to rocks or shoals found in the East River in the course of the detailed resurvey of New York Bay and Harbor; one to important changes in Monomoy Shoals, Massachusetts, and one to the discovery of a dangerous wreck on Charleston Bar. A list of the notices published is given under the head of Discoveries and Developments in this part of the Report, and statements more in detail in Part II, arranged with regard to localities and in a geographical order.

Surveys involving triangulation and topography, astronomical and magnetic work, and gravity research were carried on within the limits or on the coasts of thirty-one States, three Territories, and in the District of Columbia. Hydrographic surveys were prosecuted in the waters or off the coasts of fifteen States and two Territories.

In the general statements of progress which follow, reference is made to important investigations in terrestrial magnetism, physical hydrography, and geographical history, the results of which appear as appendices to this volume.

GENERAL STATEMENT OF PROGRESS.

I.—FIELD-WORK.

ATLANTIC COAST.—During the year ending June 30, 1886, the following operations have been included in the work of the Survey upon the coasts and within the borders of the New England States: Topographical survey of the west bank of the Saint Croix River between Calais and Eastport, Me.; topographical surveys in the vicinity of Little River, Little Machias Bay, Cross Island Narrows, and Englishman's Bay, coast of Maine; triangulation and topography of the coast of Maine in the vicinity of the towns of Machias, Machiasport, and Cutler; hydrographic surveys of Pleasant River, Englishman's Bay, Little Kennebec River, and Machias River and Bay, coast of Maine; hydrographic examinations on the coast of Maine for the Atlantic Coast Pilot; hydrographic examinations in Casco Passage and York Narrows, coast of Maine; record of observations with self-registering tide-gauge continued at Pulpit Cove, North Haven Island, Penobscot Bay, Maine; special hydrographic examinations on the New England coast; topographic resurvey of Monomoy Point, Massachusetts; continuation of geodetic operations in the State of New Hampshire; progress made in geodetic operations in the State of Vermont; determinations of trigonometrical points in the Connecticut River Valley for the topo graphical survey of the State of Massachusetts; determination of the boundary lines of towns in the State of Massachusetts; topographic and hydrographic resurvey of Cotamy Beach, Martha's Vineyard, Massachusetts; topo-

graphic resurvey of Block Island, Rhode Island; additional soundings, inshore hydrography of Long Island Sound from Hammonassett Point to Southwest Ledge Light-house; topographical resurvey of the north shore of Long Island Sound from Mulberry Point to Morgan's Point; tidal observations with an automatic tide-gauge at the Light-House on the New Haven Breakwater; hydrographic resurvey of the north shore of Long Island Sound from Welch's Point to Sheffield Island; continuation of the topographical resurvey of the northern shore of Long Island Sound between Norwalk River and New Rochelle, and inshore hydrography of Long Island Sound between Sheffield Island Light and Greenwich Point.

Upon the coasts and within the limits of the States of New York, New Jersey, Pennsylvania, and Delaware, field operations have included a topographical resurvey of the south shore of Long Island Sound from Roanoke Landing westward; extension of the triangulation for the resurvey of Long Island Sound from Eaton's Point, on the north shore of Long Island, to the eastward; topographical resurvey of the south shore of Long Island continued from Eaton's Neck to Cold Spring; tidal observations with an automatic tide-gauge at Willets Point, Long Island; topographic resurvey of the East River from Red Hook towards Throg's Neck; hydrographic resurvey of the upper part of New York Bay and of the East River; topographic resurvey of the shore lines of the North River, New York, also of shore lines on Long Island and Staten Island; hydrographic resurvey of the North River and of Upper New York Bay; magnetic observations at stations in New York, New Jersey, Pennsylvania, and Delaware; continuation of physical hydrographic survey of New York Bay and Harbor; topographic resurvey of the shore lines of Coney Island, Barren Island, and Rockaway Beach, New York Lower Bay; triangulation of Arthur Kill; topographical resurvey of the shore lines of Bergen Neck, lower part of Newark Bay, the Staten Island shore of Kill von Kull, and of Sandy Hook; tidal observations with automatic tide-gauges at Governor's Island and at Sandy Hook; topographical resurvey of the shore line of Staten Island from Stapleton southwestward; hydrographic resurvey of New York Lower Bay and Entrance; gravity determinations and researches at stations between the Hudson and the Mississippi, and between the forty-first and forty-third parallels of latitude; continuation of the primary triangulation in the eastern part of the State of Pennsylvania; reconnaissance for the extension of the triangulation in the eastern and northeastern parts of the State of Pennsylvania towards the boundary between that State and New York; reconnaissance for triangulation in the southern and western part of the State of Pennsylvania; completion of the survey of the parallel boundary between the States of Pennsylvania and West Virginia; physical hydrographic survey of the Delaware River above Petty's Island; observations of the formation and movement of ice in Delaware River and Bay; special survey of the Schuylkill River between Gray's Ferry and Bambo Point; continuation of the triangulation and reconnaissance of the southern part of the State of New Jersey and of the topographical resurvey of the coast of that State; completion of the topographic resurvey of the New Jersey shore of Delaware Bay; study of the changes in the Joe Flogger Shoal, and completion of the hydrographic resurvey of Lower Delaware Bay and Entrance.

Field operations within the District of Columbia and the State of West Virginia, and upon the coasts and within the boundaries of the States of Maryland, Virginia, North and South Carolina, and Georgia have included the completion of the survey of the boundary line, near the fortieth parallel, between West Virginia and Pennsylvania; progress made in tracing the Port-Warden lines of Baltimore Harbor; determinations of the magnetic declination, dip, and intensity at Baltimore and Washington; connection of the Washington Monument with the triangulation of the District of Columbia; continuation of the detailed topographical survey of the District; determinations of gravity at Washington; hydrographic examinations for the Coast Pilot in Chesapeake Bay and its tributaries; hydrographic examinations off Assateague, Va.; examination of line of geodesic leveling between Richmond and Fredericksburg, Va.; special hydrography in the sounds of North Carolina at the request of the authorities of that State; triangulation in the vicinity of Beaufort, and Core Sound and between Cape Fear and Little Rivers, coast of North Carolina; hydrographic examination of Frying Pan Shoals, North Carolina; also in North and South Santee Rivers, Bull's Bay, Price's, Capers, and Dewees Inlets and Charleston Harbor, South Carolina, and magnetic observations at Aiken and Charleston, S. C., and at Savannah, Ga.

Upon the east and west coasts of Florida, in the approaches to this coast, and upon the coasts,

and within the limits of the Gulf States, the following operations were in progress or completed: Deep-sea soundings off the Atlantic coast, and observations of currents and temperatures in the Gulf Stream; beach-measurement, triangulation, and topography with observations for latitude and azimuth upon the west coast of Florida between Cape Sable and Cape Romano; topographic and hydrographic surveys on that coast north of Anclote Keys; reconnaissance for primary triangulation between Atlanta and Mobile; lines of geodesic leveling carried from Mobile towards Meridian, Miss., and Carrollton, La.; hydrographic resurveys near the Chandeleur Islands and in Horn Island Pass; magnetic observations at Morgan City and on Marsh Island, southwest pass of Vermilion Bay, Louisiana; triangulation and topography between Barataria Bay and the Mermentou River; hydrography to the westward of the Delta of the Mississippi and in Coté Blanche Bay, and the measurement of a base and its connection with the triangulation near Point Isabel, coast of Texas.

PACIFIC COAST.—Upon the coasts and within the boundaries of the States of California and Oregon, of Washington Territory and of Alaska, field operations have included the triangulation and topography of the coast of California between Newport Bay and San Mateo; continuation of the series of observations at the magnetic self-registering record station at Los Angeles, Cal.; reconnaissance for the site of the primary base-line in Los Angeles County, California; continuation of the triangulation and topography of the south coast of California between Estero Point and Point Sur; occupation of stations in continuation of the primary triangulation of the coast of California north of Point Concepcion; connection of the triangulation depending upon the Pulgas Base with that depending upon the Yolo Base; occupation of stations in continuation of the primary triangulation near the southern coast of California; observations of the annular eclipse of the sun of March, 1886; magnetic observation at Presidio Station, San Francisco Peninsula; examinations of the North Farallones for the Coast Pilot, Pacific coast; shore-line resurvey of Carquines Straits and San Pablo Bay, California; resurvey of the shore-line topography of the Golden Gate and approaches; tidal observations continued at the self-registering tide-gauge station, Saucelito, Bay of San Francisco; hydrographic surveys of the coast of California off Cape Mendocino and to the southward; completion of the connection of the Koos Bay and Umpquah River triangulations; progress made in the topographical and hydrographic survey of the Umpquah River; hydrographic surveys in Tillamook Bay, off the coast in that vicinity, and in the Columbia River; continuation of the hydrography of the Columbia River towards Portland, Oreg.; inspections and examinations on the coast of Oregon and Washington Territory for the Pacific Coast Pilot; triangulation of Possession Sound and vicinity, and hydrographic surveys in Puget Sound, Washington Territory; triangulation and topography of Burrow's Bay, Rosario Strait, Washington Territory; observations for longitude at Seattle, Wash. Ter.; hydrographic surveys in Southeastern Alaska, and tidal observations continued at the self-registering tidal station at Saint Paul, Kadiak Island, Alaska.

INTERIOR STATES.—Field-work in the States between the Atlantic and Pacific coasts has included the extension westward of the primary triangulation and reconnaissance near the thirty-ninth parallel in Ohio and Kentucky; continuation of geodetic operations in the States of Tennessee, Ohio, Indiana, and Wisconsin; extension eastward in the State of Indiana of the transcontinental triangulation near the thirty-ninth parallel; gravitation work at stations near the forty-third parallel; magnetic obsevations at Detroit, Mich., and latitude observations at Madison, Wis.; extension westward of the primary triangulation in Missouri and Kansas near the thirty-ninth parallel; determinations of longitude at stations in Missouri, Kansas, and Colorado, and extension of the transcontinental triangulation near the thirtieth parallel from stations in central Utah to the eastward.

SPECIAL OPERATIONS during the year included a conference with the Inspector of Weights and Measures for the State of Rhode Island and with a committee of the Legislature of that State with regard to a standard measure of length and the establishment of a meridian line; observations of the movement of ice in Delaware River and Bay; the charge of the suboffices at Philadelphia and at San Francisco; observations at San Francisco of the annular eclipse of the sun, March 5, 1886, and examination of all the coin and bullion weights and balances of the United States Mint at San Francisco.

II.—OFFICE WORK.

Soon after the beginning of the fiscal year, events occurred which led to marked changes in the organization of the Office and in its *personnel*. The nature of these changes is stated in the Annual Report of the Assistant in charge of Office and Topography, published as Appendix No. 4 to this volume. No loss of efficiency was suffered as a result of the changes made; the tendency has been, in fact, towards increased efficiency in the several office divisions.

The practical value of the investigations in Terrestrial Magnetism, which have been carried on by the Office for many years past, is shown in part by the constant demands from local surveyors and county authorities for information in regard to the variation of the magnetic needle and its annual changes, an unusual number of queries relating to this subject having been answered during the fiscal year. An article on the magnetic declination in the United States was prepared for the use of the General Land Office.

A suggestion of importance, made by the Assistant in charge of the Office in his annual report, is that it would be well to have means provided for supplying to each county surveyor and clerk of court throughout the country copies of papers published by this Office on the secular variation of the magnetic declination and its values at upwards of two thousand three hundred stations in the United States for the year 1885. Disputes as to the actual courses of old boundary lines could often be settled were authentic information available in regard to the magnetic variation at different and remote periods, or in regard to its rate of annual change for given localities. The papers referred to were published as Appendices Nos. 12 and 13 to the Report for 1882.

Progress was made upon the drawings of eleven general charts of the coast, twenty-six coast charts, and sixteen harbor charts. Finished drawings were made of twelve charts for publication by photolithography; of these eight were published during the year. Forty-three topographic sheets were inked, either wholly or in part; one hundred and four projections were made for the use of field parties, and forty-seven tracings of original surveys, topographic or hydrographic, were prepared to meet special requests from other branches of the Government or from individuals.

Five new charts were published from engraved copper plates and one from stone; seven new editions of engraved charts were published, and nine new charts and five new editions from engraved plates begun. Additions and corrections were made to bring up to date the plates of four hundred and sixty charts. Forty thousand two hundred and twenty-six impressions from engraved plates of charts were taken in the press-rooms.

Improved processes were introduced, leading to greater accuracy in the reductions from original sheets by photography and the mounting of photographs to scale.

There were distributed during the year thirty thousand five hundred and twenty-one copies of charts, an increase of one thousand six hundred and sixteen over the number issued during the preceding fiscal year. Of this number, seven thousand eight hundred and seventy-nine were for the Executive Departments, one thousand and fifty for Congress, and nineteen thousand nine hundred and twenty-four for sale-agents. The increasing demand for charts of the Survey by ship-masters and others is shown by the large increase in the number required during the year to supply sale-agents, this number being five thousand eight hundred and eighty-nine more than during the fiscal year preceding. Of the Annual Reports, two thousand four hundred and one copies were distributed.

Tide Tables, giving in advance for the year 1887 the times and heights of high and low water at all of the principal ports of the United States were published. A third edition of subdivision No. 13 of the Atlantic Local Coast Pilot, south coast of Long Island, New York Bay, and Hudson River was prepared for publication, and the first edition of subdivision No. 20, Winyah Bay to Savannah River, was published. Free distribution was made of all Notices to Mariners printed during the year, and the appendices to the Annual Reports containing scientific papers of value were upon application supplied gratuitously.

III.—DISCOVERIES AND DEVELOPMENTS.

Special care has been taken during the fiscal year to give wide publicity to discoveries and developments, an early knowledge of which was of obvious importance to the interests of commerce and navigation. Among the Notices to Mariners issued during the year, four related to rocks or shoals developed in the East River in the course of the minute resurvey of New York Bay and Harbor; one to important changes in Monomoy Passage, Massachusetts, and one to the discovery of a dangerous wreck on Charleston Bar.

Detailed accounts of these and other dangers will be found in Part II of this Report, with the names of naval officers in charge of hydrographic parties of the Survey, to whom belongs the credit of their discovery or location.

Following is a summary of the notices issued during the year in order of date:

No. 62 (July 1, 1885) gave the location of a shoal developed near the Marquesas Keys, Florida.

No. 63 (August 24, 1885) related to ledges developed in the resurvey of Long Island Sound.

No. 64 (October 6, 1885) described a dangerous rock developed in the resurvey of East River, New York.

No. 65 (October 12, 1885) referred to other dangers found in East River.

No. 66 (October 21, 1885) described a bar which had formed between Thatcher's Island and Milk Island, coast of Massachusetts.

No. 67 (October 21, 1885) gave the location of a ledge discovered in Boston Bay.

No. 68 (November 20, 1885) related to additional dangers developed in the resurvey of East River, New York.

No. 69 (November 20, 1885) described important changes in Monomoy Passage, Massachusetts.

No. 70 (November 30, 1885) gave directions for avoiding a ledge developed in Fisher's Island Sound, Connecticut.

No. 71 (December 7, 1885) described dangers developed in the course of hydrographic examinations on the coast of Maine.

No. 72 (March 31, 1886) gave a list of important corrections made on charts published by the Office of the Survey during the quarter ending March 31, 1886.

Nos. 73 and 74 (May 12 and 31, 1886) warned navigators against a dangerous wreck on Charleston Bar.

No. 75 (May 31, 1886) related to an additional danger developed in the East River resurvey.

No. 76. (June 30, 1886) gave a list of chart corrections during the quarter ending June 30, 1886; also lists of charts canceled and new ones issued.

IV.—SPECIAL SCIENTIFIC WORK.

OBSERVATIONS OF THE ANNULAR ECLIPSE OF THE SUN, MARCH, 1886.

In Appendix No. 6 is given a tabulated statement of observations made at the station in Lafayette Park, San Francisco, of the annular eclipse of the sun, March 5, 1886, by Assistant George Davidson and other officers of the Survey. This eclipse was only a partial one at San Francisco, its greatest magnitude being about 4½ digits. The times of I and II contact were noted by five observers; Mr. Davidson observing with his equatorial of 6.4 inches aperture and magnifying power of 170, and his colleagues using reconnoitering telescopes of small apertures and low powers.

ON THE SECULAR VARIATION OF THE MAGNETIC DECLINATION IN THE UNITED STATES AND AT SOME FOREIGN STATIONS.

The publication in the Report for 1882 (Appendix No. 12) of a fifth edition of Assistant Schott's paper on the Secular Variation of the Magnetic Declination in the United States and at some Foreign Stations gave ample evidence of the large public demand for accurate information on this subject. In November, 1885, the extra edition of five hundred copies was exhausted, and a reprint of five hundred more was ordered. It has since been deemed advisable to issue a sixth edition; this will appear as Appendix No. 12 to this volume, and will contain additional observations, with extended and improved results, deduced by Assistant Schott from later investigations.

MONOMOY AND ITS SHOALS.

Few investigations in physical hydrography of greater practical importance have been undertaken by the Survey than the study of the changes in the peninsula of Monomoy and the group of shoals about it. The elaborate report on this subject by Assistant Henry Mitchell (Appendix No. 8) is based upon comparisons of the earliest charts of the locality with the results of surveys made since the year 1840 to the present time. Dangers affecting a highway of commerce through which pass about thirty thousand vessels annually, and arising from the constant shifting of the shoals, the enlargement of their areas, and the consequent diminution in width of the navigable channels, demand the most careful and thorough study to ascertain their causes and if possible guard against their effects.

REPORT ON SHORE-LINE CHANGES IN COTAMY BEACH.

The re-opening by a storm in January, 1886, of an inlet from the ocean into Edgartown Harbor through Cotamy Beach was regarded as a most desirable event, accomplishing, as it did, in a few hours a result which would have required large expenditure of time and means to obtain by engineering operations. Direct access to the ocean from the harbor through a southern inlet had been impracticable since the inlet of 1856 closed in 1869.

In Appendix No. 17 of the report for 1872 was published a detailed report by Assistant Whiting stating the results of his survey of the previous year in Edgartown Harbor, as compared with those of his former surveys of that locality. Assistant Whiting's long familiarity with and thorough knowledge of this harbor and its approaches give special value to his survey of the new opening of 1886, which he executed in the summer of that year. His report on this work appears as Appendix No. 9 to this volume.

THE DELTA OF THE DELAWARE.

As a further contribution to our knowledge of the physical characteristics of Delaware River and Bay, there is given in Appendix No. 10 a paper by Assistant Mitchell on the formation and development of the Joe Flogger Shoal, which forms the central prong in the submerged delta of the Delaware. Mr. Mitchell's treatment of the characteristics of this shoal, affords a good example of his method of comparing the results of old and new surveys, the dimensions of the shoal for the several dates of survey being compared precisely as if it were an artificial structure, such as a long mole, needing repair. By these comparisons he finds that between the years 1842–'43 and 1882–'83 the Joe Flogger lost more than a mile (nearly 1,800 meters) from its upper end, and that for this mile there was an average deepening of 10 feet on the crest of the shoal, and that the valuable channels on either side of it have not suffered; on the contrary, the *thalweg* depths have been increased—they, too, have been scoured down.

EARLY VOYAGES OF DISCOVERY AND EXPLORATION ON THE NORTHWEST COAST OF AMERICA.

For the identification of localities named by the early Spanish navigators and explorers on the Pacific coast from Cape San Lucas to Alaska, between the years 1539 and 1603, and in connection with his labors in preparing a fourth edition of the Coast Pilot of California, Oregon, and Washington Territory, Assistant George Davidson has made a special investigation of the published accounts, and of original manuscripts relating to the voyages and discoveries of these daring adventurers upon unknown coasts.

In locating the places described and geographical positions determined by Ferrelo, Cabrillo, Ulloa, and Vizcaino, in reconciling many of their discrepancies, and in tracing back to their origin the names of harbors, rivers, rocks, and headlands, Mr. Davidson has made a contribution to geographical history, the value of which is much enhanced by his systematic arrangement of material, whereby means are afforded of readily comparing dates and descriptions of the early voyageurs with the accurate and consistent descriptions of the Pacific Coast Pilot. Mr. Davidson's paper appears as Appendix No. 7 to this volume.

EXPLANATION OF ESTIMATES.

The estimates submitted to the Department for the fiscal year 1887–1888 were accompanied by the following statement:

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, D. C., October 27, 1886.

SIR: Herewith I have the honor of submitting for your approval the estimates of the appropriations required for the United States Coast and Geodetic Survey for the fiscal year ending June 30, 1888.

The aggregate of the estimates ($560,765) is considerably larger than the amount appropriated for the current year ($483,903.82), but only slightly in excess of the amount appropriated for the last fiscal year ($553,496); is less than the average amount of appropriations for many years past, and is not in excess of the amount indispensable to the economical prosecution and reasonably early completion of the work.

The increase, as compared with the appropriation for the current year, relates only to field expenses, and is accompanied by a proposed decrease of $7,093.82 in salaries, thus contemplating the accomplishment of more work for less pay than is possible under the appropriation for the current year. The amount estimated for field-work is substantially equal to the amount estimated for the current year.

In these estimates, all items of field-work are included under the classification of "Party Expenses," of which they properly form a part. They include only the kind of operations for which Congress has made annual appropriations for several years past, and identical in kind with those being prosecuted by the government of nearly every civilized country. Those items referring to operations directly along the coast are intended to leave no ground for further suggestion of the idea that completion of the primary survey of the coast is unduly delayed or that specific "hydrography" is subordinated to other operations of the bureau. To that end estimates for pushing the work as rapidly as practicable are made for operations upon uncompleted portions of the coast work, and for as much of needed hydrography as was asked for by the Hydrographic Inspector, and as can be supplied with the indispensable points, or prosecuted with the vessels, outfit, and naval officers at the command of the bureau.

No one with any experience in or responsibility for the administration of the Survey will ever dispute the proposition that the rapid and economical accomplishment of its work depends upon the ability to place its working-parties in the field—on land or at sea—so that they may work to the best advantage and as long as climatic or other conditions will permit. To transport a party and its outfit and equipage to the field involves the expenditure of an inevitable and fixed sum, whether the appropriation for its work be large or small. After defraying that fixed sum the remainder of the appropriated item is available for the accomplishment of net results, and upon the proportion of such net results to gross expenditures turns the question of real economy and efficiency. Appropriations which compel the withdrawal of parties from the field in the midst instead of at the end of a season, or after only two or four instead of four or eight months' work, enhance the ultimate cost and indefinitely delay the completion of all features of the work, and however restricted in annual amount cannot be justly characterized as economical or judicious.

The estimate for "Party Expenses" covers the pay of those temporarily employed as recorders, signal-men, hands, cooks, drivers, or boatmen, or in any other capacity in connection with field-work except as field officers or members of the permanent force; the commutation (or subsistence) of the chiefs and employés of parties; traveling expenses to and from the field and local transportation in the vicinity of field-work or in connection with it; the transportation of instruments, tents, stationery, materials, outfit, and equipage to the field and in the field, and the purchase of all requisite materials, supplies, tents, boats, stationery, and camp equipage, for use in connection with field-work, and all other necessary expenses properly incident to the prosecution of field-work.

The estimates contemplate the reduction of the number of field officers by the retirement of seven

members whose services can be best dispensed with, to be followed by the promotion of the junior members and a suspension of the grade of Aid until Congress shall provide for recruiting the force by appropriating for Aids, who should be required to enter the force under the exacting physical and mental tests now prescribed by the regulations. The estimates for the current year, as explained to the appropriations committees, contemplated a similar retirement, with, however, the numerical maintenance of the force by the appointment of a corresponding number of aids at small salaries. The contemplated reduction will prolong the annual period of field-work and shorten the annual period of office-work of those retained, without very greatly impairing the progress of the general work.

The estimate for "Pay of Office Force," while providing for an apprentice to the electrotypist and photographer in addition to the present force, and in two or three instances modifying the designations of employés, contemplates a reduction of $773.82 from the amount appropriated for the current year, the reductions occurring mainly in four or five positions occupied at less than the salaries appropriated for the current year.

In view of the opinion of the Solicitor of the Treasury that per diem employés are not entitled to leave of absence with pay, in justice to the lowest paid employés I have changed the estimates from per diem to annual salaries.

The estimates contemplate no superfluous positions. On the contrary, the proper disposal of accumulated data, and the prompt and satisfactory publication of current work, urgently require a marked increase of force in the computing, drawing, and engraving divisions of the Office.

No item of work has been estimated for, in the immediate and pressing importance of which those most competent to judge have not concurred. In fact the items of field-work submitted to me as deserving of immediate consideration and execution exceed by about $100,000 the estimates here submitted.

Very respectfully,

F. M. THORN,
Superintendent.

The SECRETARY OF THE TREASURY.

ESTIMATES.

For every expenditure requisite for and incident to the survey of the Atlantic, Gulf, and Pacific coasts of the United States and the coast of the Territory of Alaska, including the survey of rivers to the head of tide-water or ship-navigation; deep-sea soundings, temperature, and current observations along the coasts and throughout the Gulf Stream and Japan Stream flowing off the said coasts; tidal observations; the necessary resurveys; the preparation of the Coast Pilot; improving the magnetic maps of the United States and adjacent waters, and the tables of magnetic declination, dip, and intensity usually accompanying them; and including compensation not otherwise appropriated for of persons employed on the field work, in conformity with the regulations for the government of the Coast and Geodetic Survey adopted by the Secretary of the Treasury; for special examinations that may be required by the Light-House Board or other proper authority; and including traveling expenses of officers and men of the Navy on duty; for commutation to officers of the field force while on field duty, at a rate to be fixed by the Secretary of the Treasury, not exceeding two dollars and fifty cents per day each; outfit, equipment, and care of vessels used in the Survey, and also the repairs and maintenance of the complement of vessels, to be expended under the following heads: *Provided*, That no advance of money to chiefs of field parties under this appropriation shall be made unless to a commissioned officer, or to a civilian officer, who shall give bond in such sum as the Secretary of the Treasury may direct:

FOR PARTY EXPENSES:

For triangulation, topography, and hydrography of the coast of Maine in Cobscook Bay and Saint Croix River, and for off-shore soundings between Matinicus and Seguin Lights (all new work)	$12,000
For hydrography of George's Bank and Shoal off the coast of New England, and for the speedy completion of an accurate survey of the portions of the bank most used by fishermen	9,000

FOR PARTY EXPENSES—Continued.	
For resurveys: For triangulation, topography, and hydrography in the vicinity of the east end of Long Island, Block Island, Nantucket, Nantucket Shoals and approaches, and including Vineyard Sound, to be immediately available	$20,000
For physical hydrographic surveys on Monomoy Shoals	4,000
For completing the resurvey of New York Bay and Harbor	3,000
For physical hydrography in New York Harbor and its approaches	3,000
For the hydrography of the outside waters and bars south of Absecon Light; for necessary triangulation, and for continuing the topography and inside hydrography along the Atlantic coast of New Jersey (some of the hydrography is new work and the topography is virtually so because of the great changes)	4,000
For continuing physical hydrographic research in Delaware Bay and River	3,000
For observing the movement, lodgment of, and obstructions by ice in the Delaware River and noting the changes caused thereby in Cherry Island Flats, &c	200
For examinations and resurveys on the Virginia coast from Chincoteague to Cherrystone, and especially at Cape Charles and in its vicinity, including triangulation, hydrography, and topography	6,000
To continue the surveys in the vicinity of Charleston, S. C., and up the Cooper and Ashley Rivers to the head of navigation, and to continue determinations of latitude, and azimuth (which is new work), and, in connection therewith, the recovery and re-marking of old triangulation stations for their preservation, and the connection of some detached triangulation between Beaufort and the mouth of Cape Fear River, North Carolina, and the connection of the Cape Fear River triangulation with the coast triangulation at Masonborough	2,000
For hydrographic examination at Cape Lookout	500
For connecting the Blue Ridge primary triangulation with the coast triangulation at Charleston, S. C., or Savannah, Ga	2,000
To continue the primary triangulation from Atlanta towards Mobile	3,000
For continuing the survey of the western coast of Florida from Cape Sable north to Cape Romano and for hydrography off the same coast, being all new work	10,000
For triangulation, topography, and hydrography of Lakes Pontchartrain and Borgne in Louisiana	5,500
For continuing the survey of the coast of Louisiana west of the Mississippi Delta and between Barataria Bay and Sabine Pass	7,000
To make off-shore soundings along the Atlantic coast, and current and temperature observations in the Gulf Stream	9,000
For continuing the topographic survey of the coast of Southern California, of which $5,000 shall be immediately available	10,000
For continuing the primary triangulation of Southern California and for connecting the same at Mount Conness and Macho stations with the transcontinental arc, and for a primary base line in the vicinity of Los Angeles, of which $4,000 shall be immediately available	12,000
For continuing the resurvey of San Francisco Bay and of San Pablo and Suisun Bays and the Strait of Carquinez; the examination of San Francisco Bar, and entrance and the mouth of the Sacramento and San Joaquin Rivers	10,000
For continuing the survey of the coast of Oregon, including off-shore hydrography; and to continue the survey of the Columbia River from the mouth of the Willamette toward the Cascades, triangulation, topography, and hydrography	7,000
To fill up the gap in the tertiary coast triangulation between the Oregon line and Port Orford	2,500
To fill up the gap in the tertiary triangulation between Port Orford and Koos Bay	2,000
For continuing the survey of the coast of Washington Territory	9,000

For party expenses—Continued.	
For continuing explorations in the waters of Alaska and making hydrographic surveys in the same, and for the establishment of astronomical, longitude, and magnetic stations between Sitka and the southern end of the Territory	$12,000
For continuing the researches in physical hydrography relating to harbors and bars, including computations and plotting	4,000
For examination into reported dangers on the eastern, Gulf, and Pacific coasts	1,500
To continue magnetic observations on the Atlantic and Gulf slopes	1,000
For continuing magnetic observations on the Pacific coast at the Los Angeles Magnetic Observatory	1,200
For continuing magnetic observations at various temporary stations on the Pacific slope	1,000
For running an exact line of levels from Boston or Salem, Mass., to Mount Monadnock, Mount Washington, Mount Independence, and Lake Champlain	2,000
For continuing the exact line of levels from Cairo westward	2,000
For continuing tide observations on the Pacific coast, viz; at Kadiak, in Alaska, and at Saucelito, near San Francisco, in California	2,500
To continue tidal observations on the Atlantic coast at Pulpit Harbor, Maine, and at Sandy Hook, New Jersey	2,100
To continue gravity experiments, at a cost not exceeding $500 per station, except for special investigations and experiments authorized by the Superintendent at one or more stations	2,500
For furnishing points to State surveys, to be applied, as far as practicable, in States where points have not been furnished	10,000
For determinations of geographical positions, longitude parties	5,000
For continuing the transcontinental geodetic work on the line between the Atlantic and Pacific oceans	30,000
To continue the compilation of the Coast Pilot, and to make special hydrographic examinations for the same	2,500
For traveling expenses of officers and men of the Navy on duty, and for any special surveys that may be required by the Light-House Board or other proper authority, and contingent expenses thereto	5,000
For objects not hereinbefore named that may be deemed urgent	4,000
And ten per centum of the foregoing amounts shall be available interchangeably for expenditure on the objects named.	
In all for party expenses	$244,000
Repairs and Maintenance of Vessels:	
For repairs and maintenance of the complement of vessels used in the Coast and Geodetic Survey	25,000
Pay of Field Officers:	
For pay of Superintendent, $6,000 per annum	6,000
For pay of two Assistants, at $4,000 per annum	8,000
For pay of one Assistant, at $3,600 per annum	3,600
For pay of one Assistant, at $3,200 per annum	3,200
For pay of two Assistants, at $3,000 per annum	6,000
For pay of two Assistants, at $2,800 per annum	5,600
For pay of four Assistants, at $2,400 per annum	9,600
For pay of three Assistants, at $2,300 per annum	6,900
For pay of six Assistants, at $2,200 per annum	13,200
For pay of six Assistants, at $2,000 per annum	12,000
For pay of ten Assistants, at $1,800 per annum	18,000
For pay of nine Assistants, at $1,500 per annum	13,500
For pay of three Subassistants, at $1,400 per annum	4,200

PAY OF FIELD OFFICERS—Continued.

For pay of two Subassistants, at $1,300 per annum	$2,600
For pay of four Subassistants, at $1,100 per annum	4,400
Total pay of field officers	$116,800

Provided, That no new appointments shall be made to the above force until the whole number of Assistants, Subassistants, and Aids shall be reduced to fifty-two.

PAY OF OFFICE FORCE:

For one Accountant, at $1,800	$1,800
For one Accountant, at $1,400	1,400
For one General Office Assistant, at $2,000	2,000
For one Draughtsman, at $2,350	2,350
For one Draughtsman, at $2,100	2,100
For two Draughtsmen, at $2,000	4,000
For three Draughtsmen, at $1,800	5,400
For three Draughtsmen, at $1,400	4,200
For one Draughtsman, at $1,330	1,330
For one Draughtsman, at $1,260	1,260
For two Draughtsmen, at $1,200	2,400
For one Draughtsman, at $1,100	1,100
For one Draughtsman, at $940 per annum	940
For two Computers, at $1,850	3,700
For one Computer, at $1,420	1,420
For one Computer, at $1,300	1,300
For one Computer, at $1,260	1,260
For one Computer, at $1,100	1,100
For one Tidal Computer, at $2,000	2,000
For one Tidal Computer, at $1,250	1,250
For one Engraver, at $2,060	2,060
For one Engraver, at $2,000 per annum	2,000
For one Engraver, at $1,960 per annum	1,960
For two Engravers, at $1,800 each per annum	3,600
For one Engraver, at $1,565 per annum	1,565
For one Engraver, at $1,500 per annum	1,500
For one Engraver, at $1,200 per annum	1,200
For one Engraver, at $900 per annum	900
For one Contract Engraver, contract not to exceed $2,400 per annum	2,400
For one Contract Engraver, contract not to exceed $2,100 per annum	2,100
For one Contract Engraver, contract not to exceed $1,800 per annum	1,800
For one Contract Engraver, contract not to exceed $800 per annum	800
For one Electrotypist and Photographer, at $1,800	1,800
For one Electrotypist's Helper, at $500 per annum	500
For one Apprentice to electrotypist and photographer, at $500	500
For one Copper-plate Printer, at $1,700 per annum	1,700
Ror two Copper-plate Printers, at $1,330 per annum	2,660
For one Copper-plate Printer, at $1,250 per annum	1,250
For two Plate Printers' helpers, at $700 each per annum	1,400
For one Chief Mechanician, at $1,800 per annum	1,800
Fsr one Mechanician, at $1,565 per annum	1,565
For one Mechanician, at $1,330 per annum	1,330
For one Mechanician, at $1,250 per annum	1,250
For one Mechanician, at $1,175 per annum	1,175
For one Mechanician, at $900 per annum	900

Pay of Office Force—Continued.	
For one Mechanician, at $545 per annum	$545
For one Carpenter, at $1,565 per annum	1,565
For one Carpenter, at $800 per annum	800
For one Carpenter and Fireman, at $570 per annum	570
For one Night Fireman, at $550 per annum	550
For one Map-mounter, at $1,020 per annum	1,020
For one Librarian, at $1,800	1,800
For one Clerk, at $1,650	1,650
For two Clerks, at $1,500	3,000
For one Clerk, at $1,400	1,400
For one Clerk, at $1,350	1,350
For two Clerks, at $1,200	2,400
For two Clerks, at $1,000	2,000
For one Clerk, at $900	900
For one Clerk, at $1,175	1,175
For one Map colorist, at $720	720
For one Writer, at $900	900
For one Writer, at $840	840
For six Writers, at $720	4,320
For one Writer, at $600	600
For one Messenger, at $875	875
For one Messenger, at $840	840
For three Messengers, at $820 each per annum	2,460
For three Messengers, at $640 each per annum	1,920
For one Driver, at $730 per annum	730
For one Packer and Folder, at $820 per annum	820
For one Packer and Folder, at $630 per annum	630
For two Laborers, at $630 each per annum	1,260
For two Laborers, at $550 each per annum	1,100
For one Laborer, at $315 per annum	315
For one Laborer, at $365 per annum	365
For one Janitor, at $1,200	1,200
For two Watchmen, at $880 each per annum	1,760
Total pay of office force	$124,405
Office Expenses:	
For the purchase of new instruments, for materials and supplies required in the instrument-shop, carpenter-shop, and drawing division, and for books, maps, and charts	9,000
For copper-plates, chart-paper, printers' ink, copper, zinc, and chemicals for electrotyping and photographing; engraving, printing, electrotyping and photographing supplies; for extra engraving; and for photolithographing charts and printing from stone for immediate use	10,000
For stationery for the office and field parties; transportation of instruments and supplies; office wagon and horses; fuel, gas, telegrams, ice, and washing	6,000
For miscellaneous expenses, contingencies of all kinds, office furniture, repairs, and extra labor, and for traveling expenses of Assistants and others employed in the office sent on special duty in the service of the office	3,500
And ten per centum of the foregoing amounts shall be available interchangeably for expenditure on the objects named.	
Total general expenses of office	$28,500

RENT OF OFFICE BUILDINGS:

For rent of buildings for offices, work-rooms and work-shops, in Washington	$10,500
For rent of fire-proof building No. 205 New Jersey avenue, including rooms for standard weights and measures; for the safe-keeping and preservation of the original astronomical, magnetic, hydrographic, and other records, of the original topographical and hydrographic maps and charts, of instruments, engraved plates, and other valuable property of the Coast and Geodetic Survey	6,000

PUBLISHING OBSERVATIONS:

For one Computer	1,800
For one Computer	1,600
For three Copyists, at $720 each	2,160
In all	5,560

That no part of the money herein appropriated for the Coast and Geodetic Survey shall be available for allowance to civilians or other officers for subsistence while on duty in the office at Washington, or to officers of the Navy attached to the Survey; nor shall there hereafter be made any allowance for subsistence to officers of the Navy attached to the Coast and Geodetic Survey.

Total United States Coast and Geodetic Survey for the fiscal year 1887-1888. $560,765

ESTIMATES FOR PRINTING, ILLUSTRATIONS, AND BINDING FOR THE COAST AND GEODETIC SURVEY UNDER THE DIRECTION OF THE PUBLIC PRINTER.

The following estimates were submitted to the Department in compliance with a proviso contained in "An act making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1887." This proviso is as follows:

"That all printing and engraving for the Geological Survey, the Coast and Geodetic Survey, the Hydrographic Office of the Navy Department, and the Signal Service shall hereafter be estimated for separately and in detail, and apppropriated for separately for each of said bureaus."

PRINTING AND ILLUSTRATING AND BINDING FOR COAST AND GEODETIC SURVEY, UNDER THE DIRECTION OF THE PUBLIC PRINTER.

For all printing and lithographing, photolithographing, photo-engraving, and all forms of illustrations done by the Public Printer, on requisition by the Treasury Department, for the Coast and Geodetic Survey, namely: For Tide Tables, Coast Pilots, Appendices to the Superintendent's Annual Reports, published separately; Notices to Mariners, circulars, blank books, blank forms, and miscellaneous printing (including the cost of all binding and covering; the necessary stock and materials, and binding for the library and archives)	$10,434 98
ANNUAL REPORT:	
For 4,900 copies of the Annual Report of the Superintendent (including regular edition of 1,900 copies for Congress), viz, for composition, stereotyping, press-work, folding, inserting plates, binding, materials, &c	8,000 00
For photolithographing, lithographing, photo-engraying, and all forms of illustration by the Public Printer for the Annual Report	2,500 00
Total	$20,934 98

NOTE.—No engraving is done by the Public Printer for the Coast and Geodetic Survey.

PART II.

Following the geographical order of the sections of the coast and interior as given in Appendix No. 1, this part of the report presents detailed statements of progress in the several branches of the Survey, derived from the reports of chiefs of field parties, and concludes with a summary of the work of the office.

Among the reports which treat of matters of more than local interest are those relating to the special examinations made for the most available site for a light on George's Shoal; to the investigations of the changes in Monomoy and its shoals; to the advance towards completion of the resurvey of New York Bay and Harbor; to the studies of the formation and movement of ice in Delaware River and Bay; to the observations of currents in the Gulf Stream; to the progress made in the hydrographic examinations intended to furnish data for a new issue of the Pacific Coast Pilot, and to the near approach of a junction of the transcontinental triangulations which will form a geodetic connection between the work on the Atlantic and that on the Pacific.

Soon after the beginning of the fiscal year Assistant Charles O. Boutelle was succeeded in the charge of the Office by Assistant B. A. Colonna. The annual report of this officer, accompanied by the annual reports of the chiefs of the Office divisions, appears as Appendix No. 4. Statistics of the field and office work of the Survey for the fiscal year 1885–1886 are given in Appendix No. 2, and in Appendix No. 3 is published a tabular statement of information furnished to Departments of the Government in reply to special requests and to individuals upon application during the same period.

Appropriate reference was made in the last annual report to the anticipated retirement of Commander C. M. Chester, U. S. N., from the position of Hydrographic Inspector of the Survey. Having been ordered to a command afloat, after five years' service in that position, Commander Chester was relieved October 15, 1885, by Lieut. Commander W. H. Brownson, U. S. N., who was detailed at that date by the Secretary of the Navy as Hydrographic Inspector.

Lieutenant-Commander Brownson has submitted his annual report of hydrographic operations both in field and office. It is published as Appendix No. 5 to this volume. He observes at the outset that the methods of his predecessor in the conduct of the duties of his office had been so successful that his chief endeavor had been to carry out the system which that officer had inaugurated.

Lieut. J. F. Moser, U. S. N., Assistant Coast and Geodetic Survey, had charge of the work of the Hydrographic Division of the Office. Lieutenant-Commander Brownson acknowledges the great care and untiring assiduity of Lieutenant Moser in having the charts of the Survey made correct to the date of issue. As one means of effecting this, the Survey has been fortunate in securing the thorough co-operation of the Light-House Board through its naval secretary, Commander H. F. Picking, U. S. N., and it is hoped that by recent arrangement with the Chief of Engineers, results of value will be communicated from the hydrographic surveys carried on by the Engineer Bureau in connection with harbor improvements.

In order that the changes or corrections on the charts relating to buoys, new lights, dangers, &c., may be made a matter of record by publication at stated intervals, so as to be available for

the use of ship-masters, sale-agents, and others, Lieutenant-Commander Brownson recommended a quarterly issue of a Notice to Mariners which should contain a list of such changes in accordance with a scheme prepared by Lieutenant Moser. The first number of this series was issued March 31, 1886, and eventually a monthly series may be determined upon.

At the beginning of the fiscal year, the general supervision of the work on the Atlantic Coast Pilot having been assigned to the Hydrographic Inspector, the immediate charge of this work was given to Lieut. George H. Peters, U. S. N., Assistant Coast and Geodetic Survey. Hydrographic examinations made by him in the execution of this duty are referred to under their appropriate headings in this part of the report, and the progress made in the office-work is stated in the annua report of the Hydrographic Inspector. A method involving new features for the general treatment of the Atlantic coast has been devised by Lieutenant Peters, sample pages of which have been printed for distribution and criticism.

Tabulated statements of the names of officers of the Navy detailed for duty on the Survey during the fiscal year, the names of vessels and their tonnage, and of work done in the field and office accompany the report of the Hydrographic Inspector. Acknowledgment is made of the satisfactory services of Messrs. E. Willenbucher, W. C. Willenbucher, and F. C. Donn, hydrographic draughtsmen; of Mr. E. H. Wyvill, who served as clerk until promoted as draughtsman, and of Mr. George J. Vestner, who succeeded Mr. Wyvill as clerk.

SECTION I.

MAINE, NEW HAMPSHIRE, VERMONT, MASSACHUSETTS, AND RHODE ISLAND, INCLUDING COAST AND SEA-PORTS, BAYS AND RIVERS. (SKETCHES NOS. 1, 3, 16, and 17.)

Topographical survey of the west bank of the Saint Croix River between Calais and Eastport.—In continuation of the topographical survey of the coast of Maine, it became desirable to fill a gap in the topography of the west bank of the Saint Croix River between the towns of Calais and Eastport. Assistant A. W. Longfellow was directed to organize a party for this work under instructions dated July 16, 1885.

Events, at that time unforeseen, led to delay in his obtaining data from the office, but on the 5th of August he was able to begin a search for stations of the former triangulation, and by the end of October, when field operations closed, had filled in topographical details on the upper sheet of his survey from the limits of former work at Calais to within a mile of Robbinston.

The loss of many of the old triangulation points involved many determinations of new points for the plane-table work.

Mr. Longfellow remarks that as the west shore of the Saint Croix River forms the eastern frontier of the State of Maine and of the United States opposite the province of New Brunswick, in the Dominion of Canada, it may be deemed important in a military and strategic point of view to have the topography of the American shore extended farther westward and made to include in greater detail all commanding summits on the river.

The statistics of field-work, on a scale of 1-10000, which he reports, are as follows:

Miles of shore-line of ponds surveyed	2
Miles of shore-line of brooks	6
Miles of roads	11
Area surveyed in square miles	4

After the close of his field season, Assistant Longfellow proceeded to Portland and took up office-work, upon the completion of which, in November, he was placed on "waiting orders."

Topographical surveys in the vicinity of Little River, Little Machias Bay, Cross Island Narrows, and Englishman's Bay, coast of Maine.—Instructions issued to Assistant Eugene Ellicott towards the end of May, 1885, directed him to proceed to the coast of Maine, and after completing work on his unfinished topographical sheet in the vicinity of Englishman's Bay, to take up work to the eastward upon two plane-table sheets, including the coast from Moose River to Little River, and from Schooner Brook Head to Cross Island Head.

The topographical details required on the first-named sheet were completed by the beginning

of the fiscal year, and arrangements were at once made to move the party to North Cutler and begin work on the sheet to the westward, which includes the coast in the vicinity of Little River, Little Machias Bay, and Cross Island Narrows. Upon the completion of this sheet, September 10, the eastern sheet was taken up. Mr. Ellicott remarks that the work on this sheet presented many difficulties, the country being comparatively unsettled, without paths or trails, and the shore-line the roughest he had encountered east of Millbridge.

Field operations were closed upon finishing the eastern sheet in November. The scale of survey was 1-10000. Following are the statistics reported:

Miles of shore-line surveyed	46
Miles of road surveyed	39
Miles of creeks surveyed	13
Area of survey in square miles	44

During the winter Mr. Ellicott was occupied in inking his field-sheets, and in April, 1886, was ordered to report for duty at the office.

Triangulation and topography of the coast of Maine in the vicinity of the towns of Machias, Machiasport, and Cutler.—Field-work in continuation of the survey of the coast of Maine in the vicinity of Machias Bay was begun by Assistant C. H. Boyd about the middle of June, 1885, in pursuance of instructions issued May 29 of that year. Mention of Assistant Boyd's assignment to this duty was made in the last annual report. His plan of operations involved the filling in of details upon the sheet, including the shores of Little Kennebec Bay, the determination by triangulation of points needed for completing the topography of the Machias sheet, and the completion of the Machiasport sheet by the addition of a small piece of forest topography near its junction in the town of Cutler with the sheet of Little Machias Bay.

Upon the Machias sheet, the topographical survey of the west branch of the Machias River, continued from the sheet below, was carried up to the second dam above the town; the survey of the middle branch was finished to Marshfield, where it becomes a mere creek, although sea-going vessels are built upon its banks, and the survey of the village of Machias and its immediate surroundings was completed. The roads nearest to the waters of Machias Bay, Machias River, and Little Kennebec Bay were mapped, showing the communications between the towns of Jonesboro', Machiasport, Machias, Marshfield, Whiting, East Machias, and Cutler.

Two additional positions for topographic and hydrographic purposes were determined upon the sea-face of Cross Island. Points and shore-line were furnished to Lieut. E. D. F. Heald, U. S. N., commanding the hydrographic party on the steamer Bache, at work in the neighboring waters.

A number of extensive areas of dense forest were met with in prosecuting the topographical survey; these were filled in by the aid of a pocket compass and pedometer, since any attempt to penetrate these areas by cutting cross-section lines for the plane-table and level would have involved an expense equal to and perhaps exceeding the entire allotment for the season.

Mr. F. I. Mills joined the party in July, and served acceptably until the close of the season, on the 24th of October.

The statistics are:

Number of stations occupied in triangulation	9
Number of angles measured	73
Number of geographical positions determined	15
Miles of shore-line surveyed	16
Miles of roads surveyed	36
Miles of creeks surveyed	9
Area surveyed in square miles	28

After disbanding his party and storing property at Machiasport, Mr. Boyd proceeded to Portland, and upon the completion of his office-work there, early in December, was directed to report for duty at the office.

Under a subsequent heading in this section reference is made to a survey executed by him at Monomoy Point in June, 1886.

Hydrographic surveys of Pleasant River, Englishman's Bay, Little Kennebec River, and Machias River and Bay, coast of Maine.—Mention was made in the last annual report of the completion of the hydrography of Pleasant Bay by the party of Lieut. E. D. F. Heald, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Bache. At the beginning of July, 1885, in pursuance of instructions, Lieutentant Heald had re-organized his party on the Bache, and upon reaching Pleasant Bay, July 6, took up the hydrography of Pleasant River, from the line joining the river and bay, which was the limit of his work of the previous season.

After finishing this sheet, the following-named hydrographic sheets were taken up in succession and work on all of them completed with the exception of the one last named: Englishman's Bay, western and eastern parts; Little Kennebec River, Machias River, and Machias Bay. It was not found practicable to finish the hydrography of Machias Bay, owing to the advance of the season. All of the projections were upon a scale of 1–10000.

With reference to the plan adopted and executed for his work, Lieutenant Heald observes that it was to run double sets of lines of soundings intersecting at right angles, two hundred meters apart, one of the sets being as nearly as possible normal to the shore. Before beginning work upon a projection, all of the main lines to be run were drawn upon the rough sheet, so as to insure a correct spacing of the lines, and to enable the boats to be worked on any projected line in whatever locality the tide served best.

Each day's work was plotted upon the smooth sheet the following day by the executive officer of the ship, and the soundings were reduced and verified by the surgeon and engineer. Upon the completion of each sheet a duplicate was prepared by the commanding officer, upon which he personally spaced in the soundings and traced the 6, 12, and 18 feet curves of depth. This gave him a familiarity with the characteristics of the several areas sounded which he could not otherwise have obtained, showing him those localities for the more full development of which extra soundings were required.

Careful inquiry was made of local authorities as to the existence of shoals, rocks, or ledges, and where any were indicated a thorough search was made, but in no case were shoals, rocks, or ledges found that the main lines of soundings had not given evidence of.

Work was closed October 24, in pursuance of instructions. Lieutenant Heald expresses his pleasure in testifying to the zeal and ability of the following-named officers who were attached to the party during the season: Ensigns J. M. Orchard, W. C. Canfield, J. E. Craven, W. J. Sears, and H. A. Field, U. S. N.; Passed Assistant Engineer H. Main, U. S. N., and Passed Assistant Surgeon F. B. Stephenson, U. S. N. Lieutenant Heald acknowledges also his indebtedness to Assistant C. H. Boyd for tracings of shore-line of Machias River, by the aid of which he was enabled to complete the hydrography of that river to the head of navigation, and also for the aid afforded in his work by Mr. Boyd's careful marking of trigonometrical stations.

The statistics of the season are as follows:

Miles run in sounding	976
Angles measured	13,254
Number of soundings	67,722

At the end of the season the Bache proceeded to New York, where she was fitted for service on the Gulf coast, an account of which is given under the headings of Sections VII and VIII.

Hydrographic examinations on the coast of Maine for the Atlantic Coast Pilot.—Lieut. G. H. Peters, U. S. N., Assistant Coast and Geodetic Survey, has submitted a general report of his work under instructions dated July 20, 1885. Advantage was taken of the opportunities afforded by the presence of the steamers Bache and Blake on the coast of Maine, to direct Lieutenant Peters to report temporarily for duty to the commanding officers of those vessels, first to Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey, commanding the Blake, and then to Lieut. E. D. F. Heald, U. S. N., Assistant Coast and Geodetic Survey, commanding the Bache. It was desired by Lieutenant Peters to obtain all the facilities these officers could give him for making the examinations needed to revise those portions of the Atlantic Coast Pilot relating to the coast of Maine from Moos-a bec Reach to East Penobscot Bay, and in Machias Bay and vicinity.

He joined the Blake at Portland, August 12, 1885, and was attached to that vessel until

September 4. The work of Lieutenant Pillsbury in examining for reported dangers to navigation, and his experience in the special line of duty assigned to Lieutenant Peters, were of great service and afforded peculiarly favorable conditions for noting changes in depths and the collection of other data for the revision of the Coast Pilot.

Upon being detached from the Blake, September 4, at Bar Harbor, Me., Lieutenant Peters proceeded to Machiasport, and reported, September 6, to Lieutenant Heald, commanding the Bache. Much information of value was communicated by this officer.

Lieutenant Peters was detached from the Bache September 9. On his way to Washington he stopped at Portland, Me., to consult with Commander A. S. Crowninshield, U. S. N., Inspector of the First Light-House District, who with great courtesy exerted himself personally to communicate many points relating to the work in hand. Some of these were new, and others confirmed observations already made by Lieutenant Peters.

Advantage was taken of every favorable opportunity to obtain from local pilots, fishermen, and others, information bearing on the Coast Pilot work. Data derived from the practical experience of captains of coasting steamers were also noted.

In accordance with instructions, Lieutenant Peters returned to Washington September 15, and resumed office-work in connection with the preparation of the Coast Pilot for publication. In April, 1886, he was ordered to duty in Chesapeake Bay. Reference to this will be found under the heading of Section III.

Hydrographic examination in York Narrows and Casco Passage, coast of Maine.—On the way to Machiasport, in June, 1886, in pursuance of instructions to execute a hydrographic survey from Machiasport eastward to Quoddy Head, Lieut. John M. Hawley, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Bache, was directed to make an examination of the comparative advantages of Casco Passage and York Narrows, two thoroughfares much used by coasters. This work occupied two and a half days; the Bache then proceeded to Machiasport, where she arrived July 1.

Detailed notices of Lieutenant Hawley's surveys are necessarily postponed till the next annual report is published.

Record continued of tidal observations from self-registering tide-gauge established at Pulpit Cove, North Haven Island, Penobscot Bay, Maine.—An unbroken series of tidal curves has been secured for the whole year from the self-registering tide-gauge which has been maintained in operation since 1870 at Pulpit Cove, North Haven Island, Penobscot Bay. Mr. J. G. Spaulding, the observer, has exercised his usual watchful care to keep the series continuous. Observations for three years more will complete the nineteen-year lunar cycle for this station.

Special hydrographic examinations on the New England coast.—Soon after the beginning of the fiscal year, Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Blake, proceeded under instructions to make special hydrographic surveys and examinations on the New England coast. In his general report he has summarized his work on that coast, from July to November, 1885, as having been conducted in the following order, viz: Completing an unfinished survey in the vicinity of Saco Bay, from Richmond Island to the southward of Wood Island; making an examination of George's Shoal, with a view of finding a suitable location for a light-house; examining shoals reported in the vicinity of Cape Cod and in Monomoy Passage; making current observations off the eastern coast of Cape Cod; making examinations of dangers between Boston and Moos-a-bec Reach; making survey of Cape Split Harbor, Maine, and making examinations of dangers in Vineyard and Long Island Sounds.

With regard to these and to other examinations, Lieutenant Pillsbury has submitted full detailed reports, and his results have been made the basis of corrections to charts and of revisions of the Coast Pilot, and in the more important cases were published in the form of Notices to Mariners.

The need of a light on George's Shoal is concisely stated and strongly urged in Assistant Mitchell's paper, published as Appendix No. 11 to the last annual report. Lieutenant Pillsbury's examination developed facts of much interest, which are given in the following extracts from his report:

"I soon ascertained that the tide-rips (on George's Banks) indicated the shoalest water, and I went over every tide-rip I could find the whole length of the shoal.

"On the northernmost shoal I found about seventeen feet, but other than this I made no special examination of the spot, as I considered the middle of the bank a better locality for a light-house, and that was soon seen to possess better natural features. Nearer the middle I found what I suppose to be the two and one-half fathom spots of the Wilkes survey, my geographical position agreeing very closely with his published chart. The spots seemed to be on two parallel ridges running about NW. and SE., and marked very accurately by the rips. The change in depth between the ridges and the portions of the shoal immediately adjacent on either side was not very great (from six to twelve feet) and the ridges were quite narrow, but still I think they in themselves would assist materially in breaking the force of a sea crossing them against a light-house situated between, and if the elevations were raised artificially the cost would be lessened. Between the ridges the depth varied somewhat, as will be seen by the soundings.

"I endeavored to obtain some surface-soil specimens, but the current was so strong that my boring apparatus was broken. I succeeded, however, in boring a hole about five feet deep with water and a long pipe, and it seemed to be all hard, coarse sand. Ordinary sounding cups failed to bring up bottom specimens, even with shot. But I dredged on both ridges, between them, and outside both, and in each instance brought up coarse sand with a few small pebbles.

"The description of the set of the current in the Atlantic Coast Pilot seemed to be correct, but I saw no evidence of the rise and fall of tide as therein mentioned. I was on the shoal spots with the vessel at about high and low waters, and drawing eleven and a half feet I am sure she would have struck bottom if there had been a reduction of six feet on the depth we found at high water.

"In running the lines of soundings in the examination, I tried, on some of them, to keep exactly on the ridges, but I found it impossible to do so with so strong a current, and even in crossing them sometimes failed to get the lead exactly on their narrow tops. I am inclined to believe from the degree of disturbance in the edges of the rips that the depths on the ridges are about the same, and that they are nearly continuous. At the point examined, probably in a length of one thousand feet, a three and one-half fathom curve would not cross them. On both tides, the dark and rough edges of the rips were at the ridges; with a set parallel to them there was no rip, and this stage lasted about an hour each tide. The shoalest spots are easily located by these rips, the former being situated near the northern end of the latter. Of the two rips, the easternmost is much the longest, but their northern extremities are nearly in the same line. The difficulties in constructing a light-house in this very exposed situation I cannot state, but I should conclude that this position presents fewer difficulties than any other position seen on the shoal.

"Inquiries among fishermen at Provincetown developed the fact that the sand from the bottom is alive in heavy seas and sometimes comes on board their schooners when the sea breaks over them. I am told, however, that the rips described seem to be permanent, showing that even if the sand does move the ridges are maintained in about the same position; whether it is by the same sand, or fresh sand continually coming to fill in the place of that carried on, it is impossible to state."

Lieutenant Pillsbury made special reports from time to time of the results of his examinations. The number of dangers reported and searched for was seventy-nine, of which sixty-five were found either wholly or in part as reported. On the coasts of Maine and Massachusetts some of these dangers to navigation were of sufficient importance to demand the issue of Notices to Mariners. These notices, which received the usual wide and free distribution, relate to the following-named dangers:

(1) Two small ledges, hitherto uncharted, lying near Moulton's Ledge, off the entrance to Dyer's Bay.

(2) A less depth of water than shown on the charts between Bass Harbor Head and Great Gott's Island.

(3) In Muscle Ridge Channel a detached ledge, known as Emery Ledge, lying northwest of Fisherman's Island. It is now marked by a buoy painted red and black in horizontal stripes. A least depth of five and one-half feet was found upon Upper Gangway Ledge, instead of eleven feet as indicated on the charts.

(4) Between Monhegan Island and Seguin Island it was found that the group of ledges nearly surrounding Pumpkin Island had several detached spurs hitherto uncharted.

(5) A rocky patch was found about a quarter of a mile to the eastward of the northeastern end of Ram Island in Casco Bay.

[The above abstracts are taken from Notice to Mariners No. 71.]

(6) Development of a bar between Thatcher's Island and Milk Island. [Notice to Mariners No. 66.]

(7) An uncharted ledge having a least depth over it of three and one-half fathoms, and lying nearly seven-eighths of a mile NE. by E. ¾ E. from Martin's Ledge, Massachusetts Bay. [Notice to Mariners No. 67.]

(8) Important changes in Monomoy Passage, Massachusetts. [Notice to Mariners No. 69.]

Other examinations made by Lieutenant Pillsbury are referred to under the heading of Section II. In November, after his return with the Blake to New York, he was instructed to fit the vessel for deep-sea sounding and current work off the Atlantic coast. An account of this cruise will appear under the heading of Section VI.

Physical hydrography—Monomoy and its shoals.—In his annual report Assistant Henry Mitchell has submitted papers on each of the topics that have fallen under his supervision in the course of his studies in physical hydrography. These papers relate to Monomoy and its Shoals, to the Delta of the Delaware, and to New York Harbor. Reference will be made to the two last-named subjects under the heading of Section II. Mr. Mitchell's reports on the physical history of Monomoy and its Shoals and of the Delta of the Delaware appear in full in Appendices Nos. 8 and 10 to this volume. An abstract of the results which he arrives at respecting the changes at Monomoy is here given:

"The peninsula of Monomoy and the group of shoals about it present dangers that affect the commerce between the States to a greater degree, perhaps, than any other obstructions; for here, at the eastern entrance to Nantucket Sound, pass about thirty thousand vessels annually, and occasionally three hundred vessels in a single day. These vessels average two hundred tons burden, and those passing in a single day may represent, with their cargoes, three millions of dollars. These vessels not only run the gauntlet among the natural dangers of this neighborhood, but they endanger each other in narrow channels for which the charts are inadequate; for thus far it has been almost impracticable to keep accurate charts in the market because the peninsula of Monomoy is extending itself into the ocean continually, and the shoals about it are nearly all of them in motion and augmenting as they travel on. Mr. Mitchell has made a study of the physical history of these changes, which he has based upon five strictly professional surveys extending back to that of Capt. C. O. Boutelle, in 1840, and he has gone behind even these, with consistent testimony to the survey of Capt. Paul Pinkham, in 1784. Never has any remarkable physical change been the subject of closer scrutiny, and against his figures, that might otherwise seem improbable, Mr. Mitchell has placed the names of such authorities as Assistants Boutelle, Gilbert, Iardella, West, and Boyd, of the Coast Survey, who at different times made plane-table surveys that could not be excelled in accuracy. The earliest Coast Pilots of this century mentioned that this peninsula had extended a mile in the previous half century, but the Coast Survey testimony gives a rate exceeding even this.

"In the early part of this century the extremity of Monomoy made a movement to the westward and formed a nook which in time became a valuable harbor and was christened the *Powder Hole.* It was capable of holding as many vessels as were likely to be caught in that neighborhood by a winter's gale, and Mr. Mitchell counted forty vessels there in 1855. But it was short lived. The excellent chart of it, executed by the Coast Survey, was hardly in the market before a decline set in, the protecting beach began to fall back, and by 1875 this harbor of refuge was gone. The remains of a wharf, once within the Powder Hole, are now found in Nantucket Sound, and appear as a shoal upon Mr. Boyd's recent survey.

"The channel across which this great mass of sand is traveling is known as Butler's Hole, and is the grand thoroughfare for the commerce of New England with the more southern States. It is only one-half the width that it was within the memory of old sailors now living, and it is more difficult to navigate every year.

"In the western approach to Butler's Hole lies the Handkerchief Shoal, which Mr. Mitchell makes

"a special subject of comment in his report, because he had at his command several good surveys. He asserts that this shoal extended itself across the sailing course of the great fleet three thousand feet in twenty-two years, and added to its bulk (above the eighteen-feet plane) seven million cubic yards of sand. Other shoals, to which the study is being extended, exhibit changes of volume and position, and these phenomena are found to be coincident with a great encroachment of the ocean upon the sea front of Cape Cod, more especially at Chatham, where portions of the town, together with two light-houses, have fallen a prey to the dash of the waves.

"At present the whole group of phenomena is without explanation as a freak of the ocean, and the damage to the channels that is being done may be beyond human effort of prevention; but the Coast Survey has undertaken to make a diagnosis of the case as an incident to the perfection of its chart."

Mr. Mitchell's report is accompanied by a paper furnished by Assistant Charles O. Boutelle, referring to his topographical survey of the island of Monomoy made in 1840 at the request of the authorities of the town of Chatham, and by a tracing showing the changes in Monomoy and its shoals between 1784 and 1875, and one showing the growth of Handkerchief Shoal, prepared by Mr. H. F. Bothfield, employed as a special expert in such comparisons.

Resurvey of Monomoy Point, Massachusetts.—In order to obtain further data for determining the rate and extent of the changes taking place at the southern end of the island of Monomoy, instructions were issued to Assistant C. H. Boyd, June 8, 1886, to make a resurvey of the shore-line north of and around the Point of sufficient extent to afford a comparison with his own survey of 1868, and with other surveys. Subassistant C. H. Van Orden was directed to aid Mr. Boyd in this work.

Having established themselves at the Point, Messrs. Boyd and Van Orden searched for and recovered stations of the triangulation of 1868, and then chained short bases on lines to Nantucket Great Point, and Harding's Beach light-houses, distant twelve and eight miles respectively. Upon these bases a small plane-table triangulation was made, and the resurvey of the shore-line completed from a mile north of Monomoy light on both ocean and bay sides around the Point and the Powder Hole.

The low-water line was measured as carefully as the surf would allow, all portions being visited at low tide to get an accurate delineation. That part of the "Shovelful Shoal" showing just before low water was determined by the intersection from shore stations, as the surf ran too high to permit of landing upon it. The position of the Light-Ship and that of the buoys upon shoals in sight was also determined.

Much unfavorable weather prevailed, some part of each day being lost from either rain or fog, but as the observers were always on the ground, no opportunity of work was lost, and on June 21 the survey was completed.

The results obtained are:

Miles of high-water shore-line surveyed	8
Miles of low-water shore-line surveyed	7
Area of survey in square miles	2

Mr. Boyd reports that some marked changes were developed within the limits of this examination. A mile and a half north of the Light-House there was found an accumulation of sand some two hundred and fifty meters to seaward upon the shore-line, and gradually diminishing in width till near the Light-House, where the shore-line is nearly the same as eighteen years ago. At the extreme end of the Point the sands have built out one hundred and twenty-five meters. But the most marked change is the total destruction of the Powder Hole as a harbor of refuge. The eastern sand spits making this shelter have beaten in upon the harbor one-fourth of a mile, and the entrance is so silted up that it cannot now be entered with a sail-boat near low water. Formerly this was a safe and commodious harbor for a large fleet of coasters in two fathoms water. Mr. Boyd suggests that a study of the source and movement of material along the eastern face of Cape Cod, and of its accumulation on the Point and on the shoals adjacent, would lead to the adoption of such engineering expedients for its control and utilization as would restore the Powder Hole to its former value as a safe and roomy harbor for coasting vessels.

Continuation of geodetic operations in the State of New Hampshire.—Under instructions to take up field-work as soon as practicable after the beginning of the fiscal year, Prof. E. T. Quimby, Acting Assistant, had completed by July 1 the needed preparations for occupying a station in Southeastern New Hampshire. His party was established in camp on Patuccawa Mountain, in the town of Nottingham, Rockingham County. This station is one of those in the primary series along the New England coast; it has an elevation of about eight hundred feet above the sea, and was first occupied by Superintendent Bache in 1849.

Unfavorable weather delayed the beginning of observations until July 7. On August 2, work at Patuccawa was finished and the camp was moved to Garrison Hill, in the town of Dover, Strafford County. This was accomplished, notwithstanding a heavy storm, by August 4. Garrison Hill is a place of resort during the summer, and a tower for the use of visitors has been built on its summit. This tower with its flag-pole rising from the center was used as a signal to be observed upon from other stations, but as it could not be occupied it was necessary to build a tripod and scaffold so as to elevate the theodolite about twenty feet and overlook the small growth of trees with which the hill was covered. The point occupied was therefore an eccentric one.

After completing the observations at Garrison Hill, September 11, and packing and storing his camp equipage, Professor Quimby visited stations Blue Job and Catamount, points in the secondary series, to measure a few angles. Field operations were closed September 28. The following statistics are reported:

Number of pointings with horizontal circle	1,700
Number of horizontal directions determined	202
Number of pointings with vertical circle	720
Number of vertical angles measured	21
Number of micrometer measurements for heights	212

Progress made in geodetic operations in the State of Vermont.—Field-work in continuation of the triangulation of the State of Vermont was begun July 2 by Prof. V. G. Barbour, Acting Assistant. Between that date and August 31, when observations were closed, under instructions, three stations were occupied. The first of these was on Rochester Mountain, near the town of that name, in Windsor County, the second on Goshen Mountain, in Addison County, a station quite difficult of access, and the third at Landon, about eleven miles to the westward of Goshen and near the western limits of the State. Landon is easy of access and commands an extensive view to the north.

In addition to the observations upon the signals of the triangulation, advantage was taken of every opportunity to determine church spires and other prominent objects in the numerous villages visible from the stations occupied. Among these were the dome of the College at Middlebury, Vt., and church spires in Rutland, Brandon, Randolph, Braintree, Barnard, Whiting, Shoreham, Salisbury, and West and East Sudbury, Vt. Observations were made also on the tower on Snake or Grandview Mountain, and upon church spires in Moriah and Minerville, N. Y., and the High-School building at Fort Henry, N. Y.

Co-operation with the U. S. Geological Survey in making a topographical survey and map of the State of Massachusetts.—Assistant Henry L. Whiting has submitted a report of the duties assigned to him during the last fiscal year as a member of the Board of Commissioners on the part of the State of Massachusetts, organized to co-operate with the U. S. Geological Survey in making a topographical survey and map of the State, and also by taking the general direction of the triangulation furnished to the State by the Coast and Geodetic Survey.

A full statement of the details of this work, which was executed by Assistants Perkins and Van Orden, who were detailed to act under Mr. Whiting's general supervision, is given in the printed report of the commissioners, from which have been condensed the reports which appear under the two headings immediately following. Duplicates of all the results of the work of Messrs Perkins and Van Orden have been furnished by direction of the Superintendent for the use of the commissioners.

Since the close of the field season and during the winter and spring Mr. Whiting's personal attention has been given to the affairs of the State Commission in matters pertaining to its business management and official dealings with the State Government. The accounts of the State Survey

in the expenditures by the U. S. Geological Survey and by the Commission have passed through his hands for approval and presentation to the State officials.

During the month of June Mr. Whiting took up, under instructions, an examination and survey of an opening which has been made recently by the sea in the south beach of Edgartown Harbor, Martha's Vineyard. Reference to this work will be found under a subsequent heading in this section.

Determination of trigonometrical points in the Connecticut River Valley for the topographical survey of the State of Massachusetts.—In pursuance of instructions issued in accordance with the provisions of the act authorizing the Coast and Geodetic Survey to determine points in each State which shall make provision for its own topographical surveys, Assistant F. W. Perkins was directed to proceed to Boston in June, 1885, and confer with Assistant H. L. Whiting, one of the Commissioners of the State Survey. The topography of the Connecticut River Valley being then in progress, it was deemed advisable to have a number of additional trigonometrical points determined by Mr. Perkins, those available from the Borden triangulation being too few.

With regard to the points of the Borden survey (1832–1838) Mr. Perkins observes that they were well marked and were recovered at far less expense of time than could have been anticipated from the fact that there were no descriptions of the localities. They were known officially only by their latitudes and longitudes. He notes, however, what appears to be a want of care in the marking of the ends of the Hatfield Base, upon the measurement of which Mr. Borden expended so much care and ingenuity, and upon which his trigonometrical survey of the State rests. The northern end of this base is marked at the surface only by a rough block of stone without any inscription, while the southern one has no surface mark.

Mr. Perkins' triangulation was for the greater part included within the limits of the counties of Franklin, Hampshire, and Hampden, and extended over an area of about nine hundred square miles, at a cost to the State and the United States of one dollar and ninety two cents per square mile. He was aided by recorders supplied by the State. Of these Mr. E. C. Peirce served during the greater portion of the season, and during the latter portion Messrs. J. Carleton Terry and Stockwell Betts. To these gentlemen Mr. Perkins expresses himself as indebted for earnest and efficient assistance. He refers also to the general interest taken in the work and disposition to facilitate it shown by all classes of the people.

Field operations were closed November 3, after which the time of the party was devoted exclusively to the revision and duplication of the records and computations, all of which have been completed.

The statistics of the work are as follows:

Number of old points recovered	11
Number of signals erected	34
Number of stations occupied	19
Number of geographical positions determined	137
Number of elevations determined	27
Number of points observed upon	314
Number of vertical angles measured	403
Number of horizontal angles measured	2, 690

It is to be noted that the number of points mentioned as determined in geographical position only partially represents the results of the work, since many of the single directions measured serve to verify doubtful positions in the older Borden survey, or are partial determinations of points which will be completed in the course of the extension of the triangulation.

Towards the end of November Assistant Perkins was assigned to duty on the Gulf coast. Reference to this will be made under the heading of Section VIII.

Determination of the boundary lines of towns in the State of Massachusetts.—The Commissioners of the Topographical Survey of Massachusetts having made application for the detail of an officer of the Coast and Geodetic Survey to determine by triangulation the boundary lines of the cities and towns in the Commonwealth, Assistant C. H. Van Orden was detailed in June, 1885, for this duty, with instructions to report to Assistant Henry L. Whiting, one of the Commissioners of the

State Survey. It was held by the Commissioners that the points of triangulation determined in connection with the boundary lines would also form a part of the system of points needed as a basis for the topographical survey, these respective branches of the survey being cognate in their nature. It was borne in mind that the topographical survey did not undertake to determine lines of political and municipal division except in cartographic form, and it was thought that the addition of data from which the values in figures of the lines in the various town boundaries could be taken would enhance the value of the whole work.

After conference with Mr. Whiting, Mr. Van Orden took the field in June, 1885. His first work was a reconnaissance of the primary side of Blue Hill–Prospect Waltham, and its connection with the corners of the town of Hyde Park, Norfolk County. Thence he worked easterly, including and completing the town boundaries of Milton, Quincy, Braintree, Randolph, Holbrook, and Weymouth, in Norfolk County, and of Hingham, Cohasset, Scituate, and South Scituate, in Plymouth County. In Norfolk County he partially completed the boundaries of the towns of Dedham, Canton, and Stoughton, and in Plymouth County those of Brocton, Abington, Rockland, and Hanover. To do this it became necessary to use two additional points in the primary triangulation, Scituate, and Prospect Hingham. From the line joining these points as a base, the triangulation was carried southward to the old line, Alden–Monk's Hill.

In coming down from the primary sides to the town corners, the work done establishes points that will be very useful in future surveys. All of such points have been permanently marked and descriptions of them made. Field operations were closed, owing to the advance of the season, in December. The results are summarized in the following statement of statistics:

Number of points of former triangulation occupied	4
Number of points of new triangulation determined	152
Number of points at angles in town lines determined	57
Total number of points occupied and determined	213
Area in square miles covered by triangulation	500
Number of towns of which boundaries are completed	11
Number of towns of which boundaries are partially completed	7
Number of objects determined, such as church spires, &c	22
Number of points within completed town boundaries permanently marked and described as bases for future surveys	45

With regard to this work the Commissioners in their annual report express their belief that its completion in a manner commensurate with the scientific and accurate standard of the trigonometrical surveys already made by the State and the United States will form the best basis for a cadastral or property line survey of a State yet provided in this country.

Survey of a recent opening in Cotamy Beach, south side of Edgartown Harbor, Martha's Vineyard.—The value of Edgartown Harbor as a harbor of shelter for vessels caught by bad weather in the approaches to Cape Cod was dwelt upon by Assistant H. L. Whiting in his elaborate report on shore-line changes in that harbor, published as Appendix No. 17 to the Report for 1872. In that paper he remarks that the importance cannot be questioned of an inlet or passage-way from the harbor southward for the smaller pilot-boats, which in certain winds and storms can safely and quickly reach vessels needing a pilot off Muskeget Channel, through a southern inlet, when it would be impossible for them to round Cape Poge or reach the ground of danger by any other route.

Since 1869, when the eastern inlet into Cotamy Bay was closed by the action of storm and tide, the beach remained intact until January, 1886, when a new opening occurred near the center of the beach, having a width of between nine hundred and one thousand feet. It was deemed important to have the exact location, extent, and character of the new inlet determined by a resurvey, and this duty having been assigned to Mr. Whiting, he took the field early in June, and at the close of the fiscal year had erected the necessary signals and occupied a number of stations. The results of this resurvey will be made the subject of a special report by Mr. Whiting, which will be published as Appendix No. 9 to this volume.

Topographical resurvey of Block Island, Rhode Island.—In connection with the general resurvey

of Long Island Sound, instructions were issued towards the close of April, 1886, for a topographical resurvey of Block Island at the eastern entrance to the Sound. Assistant W. H. Dennis, to whom this work was intrusted, reached the island May 1, and immediately organized a party for the survey.

During May and June Mr. Dennis reports that the weather was unfavorable, and that the irregularities of surface in the island, and the great amount of artificial detail, made progress less rapid than he had desired. Upwards of one-half of the area was completed, however, by June 30. To that date the statistics are:

Miles of shore-line surveyed	12
Miles of roads surveyed	35
Shore-line of ponds, &c., surveyed	25
Area surveyed in square miles	7

SECTION II.

CONNECTICUT, NEW YORK, NEW JERSEY, PENNSYLVANIA, AND DELAWARE, INCLUDING COAST, BAYS, AND RIVERS. (SKETCHES Nos. 1, 3, 4, 16, and 17.)

Examination of a danger to navigation in Fisher's Island Sound.—A rock having been reported, not laid down on the charts, in Fisher's Island Sound, east of the West Harbor, Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey, was directed to examine the locality. His report led to the publication of a Notice to Mariners (No. 70), bearing date of November 30, 1885, and describing a pinnacle rock having but seven feet of water upon it, lying about midway between Middle Clump and the nearest point of Fisher's Island.

Other dangers to navigation, discovered and reported by Lieutenant Pillsbury, are noticed under the heading of Section I, and his deep-sea sounding and current work under the heading of Section VI.

Topographical resurvey of the south shore of Long Island Sound, continued from Roanoke Landing westward.—At the beginning of the fiscal year Subassistant W. I. Vinal was at work, in pursuance of instructions, in making a resurvey of the shore-line of Long Island. At that date he had surveyed a narrow belt of topography on the shore from Peconic westward to Roanoke Landing. The season being favorable, and the facilities for transportation good, satisfactory results were obtained throughout the season, which closed November 15 at Port Jefferson Harbor and Setauket Beach.

The survey is shown upon six plane-table sheets on a scale of 1–10000. Mr. Vinal reports the following statistics:

Miles of shore-line surveyed	51
Miles of roads surveyed	49
Miles of creeks and ponds surveyed	8
Area surveyed in square miles	14

Mr. W. B. Mapes was attached to the party from July 1 to the end of the season. Duty assigned to Mr. Vinal during the following winter on the Florida coast is referred to under the heading of Section VII.

Additional soundings—In-shore hydrography of Long Island Sound, from Hammonassett Point to Southwest Ledge Light house.—Some lines of soundings being needed to fill up parts of the resurvey of Long Island Sound in 1884, which had been unavoidably left incomplete, instructions were given to Lieut. F. H. Crosby, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Gedney, to take up that work at the opening of the season in 1886.

Three projections, scale 1–10000, were furnished to Lieutenant Crosby, with limits as follows: (1) From Hammonassett Point to Sachem's Head; (2) from Sachem's Head to Negro Heads, and (3) from Negro Heads to Southwest Ledge Light-house.

Tide-gauges having been established at Faulkner's Island and at Money Island, soundings were begun June 18, and at the date at which this report closes hydrographic Sheet No. 1 had been finished and No. 2 partly.

The further progress of this work will be stated in the next annual report.

Lieutenant Crosby had the aid of the following-named officers attached to the Gedney: Ensigns J. S. Watters, G. W. Street, and C. E. Sweeting, U. S. N.

He reports the following statistics to June 30, 1886:

Miles run in sounding	79
Angles measured	1,277
Number of soundings	4,725

Hydrographic surveys made by Lieutenant Crosby at the entrance to Delaware Bay and on the Gulf coast are referred to elsewhere under the heading of this section and under that of Section VII.

Topographical resurvey of the north shore of Long Island Sound from Mulberry Point to Morgan's Point.—As mentioned in the last annual report, Assistant W. H. Dennis took the field, in pursuance of instructions in May, 1885, to carry on the topographical resurvey of the north shore of Long Island Sound. His work was projected on two plane-table sheets, each on a scale of 1–10000. The first one taken up extended from Guilford on the east, to and including the town of Branford. The shore-line was first finished and a tracing furnished to the office. The delineation of the great number of ledges and rocks, showing at low water only, took much time, and yet contributed apparently but little to the statistics of work done. Topographical details on this sheet were filled in to a distance of from three-fourths of a mile to two miles back from the shore. In September, on the completion of the first sheet, the second one was taken up and finished by the 26th of October, when field operations closed. This sheet joins with the first one on the east and connects with the work of Assistant R. M. Bache on the west, near New Haven Harbor.

Mr. Dennis reports that during the greater part of the season, or up to the 1st of October, he was favored with exceptionally fine weather for field-work.

Lieut. G. Lange, of the Norwegian General Staff, who had been assigned to the party as aid, and whose services were highly valuable, was relieved on the 20th of July and assigned to service with the party of Assistant Eimbeck, engaged on the transcontinental triangulation near the thirty-ninth parallel.

Mr. E. A. Trescot joined the party as aid and served in that capacity till the 24th of September.

The statistics of the season are as follows:

Miles of shore-line surveyed (including low-water line)	39
Miles of roads surveyed	81
Miles of creeks surveyed	28
Miles of marsh-line surveyed	54
Area surveyed in square miles	21

During the winter Mr. Dennis was assigned to duty at this office, and in April was instructed to organize a party for the resurvey of Block Island and of the shore of Block Island Sound from Watch Hill easterly.

Tidal observations with an automatic tide-gauge at the light-house on the New Haven Breakwater—Also at Willet's Point, western end of Long Island Sound.—Reference was made in the last annual report to the establishment of a self-registering tide-gauge at the Light-House on the New Haven Breakwater, and to the maintenance of a tidal record there for four months in 1884. For the uses of the hydrographic resurveys in Long Island Sound the record was begun again in the spring of 1885, and kept continuously till the gauge was washed away by a storm in October of that year.

At Willet's Point, Long Island, New York, a self-registering tide-gauge which had been loaned to the Corps of Engineers, U. S. Army, was set up, and an original record of observations, extending from August 15 to October 12, was furnished to this office.

Hydrographic resurvey of the north shore of Long Island Sound from Welch's Point to Sheffield Island.—In continuation of the hydrographic resurvey of Long Island Sound, Lieut. Sumner C. Paine, U. S. N., Assistant Coast and Geodetic Survey, was directed, in June, 1885, to organize his party on board of the schooner Ready and take up the hydrography of that part of the Sound between Welch's Point and Sheffield Island.

The Ready left New York July 2 and anchored next day near Charles Island, Milford Roads. The area included in the survey was covered by four hydrographic projections, each on a scale of 1-10000. Lieutenant Paine's general plan for the work was to run six lines of soundings to the mile, normal to the coast, crossed by four lines in an east and west direction ; to traverse the coast-line and islands, and develop especially the shoals and rocks. This scheme was generally carried out; on the fourth projection, however, which includes the Norwalk Islands, the obstructions to navigation were found to be so numerous that it was deemed advisable to double the general lines in each direction.

To obtain a plane of reference for the soundings, tide-gauges were set up on the Fish House Wharf, Welch's Point; on Lewis's Wharf, East Bridgeport; on the wharf at George's Hotel, Black Rock Harbor, and on the south bank of the Saugatuck River where it makes its first bend to the westward. Bench-marks were established for each of these gauges, and the mean low water at different points was obtained by comparison with the record of the automatic tide-gauge on the New Haven Breakwater. This gauge, which had been located there in 1884, was re-established in May, 1885, and the record kept up till October of that year, when it was carried away by a gale

Lieutenant Paine remarks that he found no great changes in the soundings as given on the existing charts. Off Stratford Point, however, about two miles south and from one and a quarter to one and a half miles west of Stratford Light-house, there are several spots with from twenty to twenty-three feet of water on them, surrounded by depths of from twenty-five to thirty feet. Unfavorable weather prevented as thorough a development of this locality as it was desired to make.

From Welch's Point to Norwalk the entire coast abounds in oyster-beds planted in from five to six fathoms of water; there are also extensive beds in protected places inside the Housatonic River and between the Norwalk Islands and the mainland.

The rivers included in the survey have nearly all had their channel lines dredged out during the past few years, and during last summer a great deal of work was done about the shoals at the mouth of the Housatonic River. The entrance to this river has been deepened two feet, and there is a fair anchorage for small vessels inside. In the Wepawaug River at Milford the channel has been dredged but a short distance to a small wharf near the mouth where the oyster steamers moor, and there is practically no anchorage inside the bar, the channel being narrow and shallow and surrounded by mud flats. In the Pequonnock River at Bridgeport the channel has not only been dredged out, but a great deal of dredging has been done above the upper beacon on the west edge of the channel. Here, there is a fair anchorage for small vessels in about twelve feet of water; a short scope of chain must, however, be used as there are mud flats directly astern and close aboard in an easterly wind.

The Mill River at Southport is a mere tide-water creek ; there is no anchorage inside for vessels drawing over two feet. In the channel of the Saugatuck River at Westport there is plenty of water, but the channel is in some places very narrow. There is a first-rate anchorage in the spot marked on the existing charts for that purpose. In the Norwalk River there is a fair anchorage above Dorlon's Hotel for small vessels.

Channel lines have been run in all the rivers. They are generally crooked, and it impossible to give any range which would assist strangers in running up the rivers. A pilot should always be employed. Lieutenant Paine observes also that a change is needed in the description of Charles Island (subdivision 11, pp. 358–359, Atlantic Coast Pilot), the large white house there mentioned having been burned and the fish-oil factory moved to Welch's Point, where the tall chimney makes a good landmark. On the southern end of the island four poplars are noticeable, three in one group and the fourth quite near them.

Ensigns T. D. Griffin and C. E. Sweeting, U. S. N., were attached to the party during the season. Mr. G. E. Kent served as recorder.

At the close of the season, November 11, the Ready was taken to the navy-yard, Brooklyn, N. Y. The statistics reported by her commander are as follows:

Miles run in sounding	598
Angles measured	6,872
Number of soundings taken	42,244
Number of specimens of bottom preserved	55

Extension of the triangulation for the resurvey of Long Island Sound, and of New York Harbor, from Eaton's Point eastwardly on the north shore of Long Island, and from the Hudson River to beyond Throg's Neck.—During the summer and autumn of 1885 the triangulation for the resurvey of Long Island Sound and of New York Harbor was advanced by Assistant Gershom Bradford, whose party took the field for that purpose under instructions dated July 20. Mr. Bradford's first work was to fill a gap of about twenty miles in the triangulation on the north side of Long Island, between Eaton's Point and Miller's place. He found enough points of the old triangulation to determine all of the subordinate points needed and to establish the position of Stratford Shoal Light-house from two bases. By September 12 the work was finished. Its statistics are as follows:

Stations of old triangulation recovered	6
Geographical positions determined	12
Horizontal directions observed	75
Number of separate pointings	2,468

The points needed by the topographical parties were furnished them from the field computations as the work advanced.

On the 21st of September Mr. Bradford transferred his party to College Point, Long Island, and began search for such points of the triangulation executed in 1834 and 1855 as would enable him to furnish positions to the topographic and hydrographic parties engaged in the resurveys of the East River and Long Island Sound. The principal stations recovered were Cypress Hill and Clarke on Long Island, and Highwood[2] between West Hoboken and Weehawken, N. J. These stations are located several miles inland from that part of Long Island Sound which was to be surveyed, and the chief difficulty was to find a new point or points intervisible with these three stations, and also with points to be established on the shores of the Sound. The smoke which usually overhangs New York City and vicinity seldom clears enough to admit of good seeing on long lines, and the trees which have grown up since the former triangulation was executed could not be removed except at great expense, as they stand on valuable estates. After some delay Mr. Bradford succeeded in finding a station (Ferber's cupola) in College Point and a tower (Memorial Church) in New York City, which gave the connection desired, and the work was then pushed forward with but little interruption till the 10th of November, when field operations were closed.

The statistics are:

Stations of old triangulation recovered	7
Geographical positions determined	23
Horizontal directions observed	106
Number of separate pointings	1,686

During the winter and spring Mr. Bradford was engaged on office duty.

Continuation of the topographical resurvey of the north shore of Long Island Sound between Norwalk River and New Rochelle.—Assistant Charles Hosmer, to whom was assigned the continuation of the topographical resurvey of the north shore of Long Island Sound from Norwalk River to New Rochelle, reports that he organized his party and began work May 25, 1885, and continued in the field till October 28, when the party was discharged.

Mr. J. H. Turner, Aid, rendered efficient service during the season.

The statistics are:

Miles of shore-line surveyed	180
Miles of roads	110
Miles of creeks	20
Area surveyed in square miles	23

During the winter and spring Mr. Hosmer was engaged in office work, and towards the close of the fiscal year was instructed to resume work from the limits of his survey of the preceding season. At the date at which this report closes he had been in the field a month, and was making satisfactory progress.

Inshore hydrography of Long Island Sound between Sheffield Island Light and Greenwich Point.—At the opening of the season in 1886 preparations were made, in pursuance of instructions, by Lieut. D. D. V. Stuart, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner Palinurus, to resume the inshore hydrography of the western part of Long Island Sound.

Having reached the working ground off Sheffield Island May 10, tide gauges were established at Wilson's Point and at Greenwich, and soundings were begun May 18 just west of Sheffield Island Light. On the completion of work in this vicinity Lieutenant Stuart shifted his anchorage to Darien Harbor, where he established a tide-gauge and continued work.

On June 15 he removed his tide-staff to Stamford Light and continued the hydrography, having by June 30, the date at which this report closes, reached Greenwich Point.

The progress of this portion of the Long Island Sound resurvey will be stated in the next annual report.

Ensigns W. G. Hannum and M. Johnston were attached to the Palinurus.

The statistics to the close of the fiscal year are:

Miles run in sounding	4
Angles measured	76
Number of soundings	396

Topographical resurvey of the south shore of Long Island Sound from Smithtown Bay to Matinicock Point.—At the beginning of the fiscal year the party of Subassistant W. C. Hodgkins was engaged in making a resurvey of the shore-line of Long Island in the vicinity of Eaton's Neck and Lloyd's Neck, having been organized for that purpose in pursuance of instructions issued in May, 1885. Field-work was continued until November 14, at which time the shore-line had been resurveyed from a point on Smithtown Bay at the junction of Eaton's Neck with the main shore to Matinicock Point at the entrance to Hempstead Bay.

The results are shown on three plane-table sheets on a scale of 1-10000.

In the course of the season it became necessary to determine by triangulation some additional points in the vicinity of Huntington, Long Island.

Mr. J. W. G. Atkins, Acting Aid, was attached to the party till near the close of the season, rendering diligent service in both field and office work.

The statistics reported are:

Number of angles measured in triangulation	37
Number of positions determined	8
Number of miles of shore-line surveyed	135
Number of miles of roads	44
Number of miles of creeks, low water and marsh-line	86
Approximate area surveyed in square miles	7

After the completion of this survey Mr. Hodgkins proceeded under instructions to the office, where he was occupied till early in January in perfecting the records of his season's work. Duty on the North Carolina coast, subsequently assigned to him, is referred to under the heading of Section IV.

Topographical resurvey of the shores of the East River from Red Hook towards Throg's Neck.—At the beginning of the fiscal year, as mentioned in the last annual report, Assistant E. Hergesheimer had been in the field about two months, engaged under instructions in that part of the resurvey of New York Bay and Harbor which included the shores of the East River from Red Hook and the Battery towards Throg's Neck.

Between May 1 and July 16, 1885, he had carried the shore-line topography, upon a scale of 1-10000, to the south end of Blackwell's Island, comprising an area of one and a half square miles, fifty miles of wharf and shore line, and twenty-two miles of streets.

On July 17 he took up a detailed topographical survey of Blackwell's, Ward's, and Randall's Islands and the adjacent shores of East River and Harlem River on a scale of 1-5000. This survey was made with great care for completeness and accuracy, and comprised an area of one and three-tenths square miles, twenty-six and a half miles of shore-line, and thirty-six miles of streets and roads.

This detailed survey was completed October 6. The plane-table sheet including it was repro duced for early publication by photolithography on the original scale. Also the first named sheet from Red Hook and the Battery to Blackwell's Island.

From October 7 to October 28, when field operations were closed, Mr. Hergesheimer continued the topography of the East River to Flushing Bay on a scale of 1–10000, surveying nineteen miles of shore-line and a little more than one-fourth of a square mile in area.

An examination of these statistics will show how unfair it would be to estimate the cost and amount of topography by the area surveyed without reference to the scale of the work and the great quantity of detail involved in close surveys of water fronts and wharf lines.

A summation of the statistics of the season's work upon both the 1–5000 and 1–10000 scale gives:

Miles of wharf and shore-line surveyed	96
Miles of streets surveyed	58
Area surveyed in square miles	3

As a general rule, the wharf-line survey was limited to a depth of one block from the water front.

After finishing his field-work Mr. Hergesheimer was ordered to office duty. During the winter he inked the two completed sheets of East River for photolithographing, and then reduced to 1–10000 scale for the same purpose the detailed surveys of the Hudson River front of parts of New York City and New Jersey.

On March 11 he was directed to report to the Assistant in charge of the office for duty as Chief of the Drawing Division.

Continuation of the topographical resurvey of the shores of the East River from Port Morris and Flushing Bay to Throg's Neck and Willet's Point.—The topographical resurvey of the shores of the East River, which had reached Flushing Bay at the end of October, 1885, under the charge of Assistant E. Hergesheimer, as stated under the previous heading, was resumed by Assistant C. T. Iardella, under instructions dated in April, 1886.

Early in May he began the survey at Port Morris, on the north side of East River, continued it to Throg's Neck Light-house, and carried it on the south side of the river from Flushing Bay to Willet's Point. This work was finished June 16. Beginning then at West Chester Wharf, on the north shore of Long Island Sound, he completed the shore-line resurvey southwestwardly to Throg's Neck, and subsequently took up the resurvey of shore-line from Willet's Point to Little Neck on the south shore of the Sound, joining at the last-named locality with work previously executed by Assistant Hosmer.

Reference will be made in the next annual report to the progress of Mr. Iardella's work after June 30, the date at which this report closes. On the north side of Throg's Neck great changes were found since the survey of 1857–'59, the shore-line having washed away some one hundred and fifty meters (four hundred and ninety-two feet). A heavy stone wall is being built around Fort Schuyler, which protects the north shore from any further encroachments. On the south side of the fort at ordinary high tide the water is now close to the road leading into it.

Statistics of this survey to the end of the fiscal year are as follows, scale 1–10000:

Miles of shore line surveyed	27
Miles of low-water line	23
Miles of roads	7
Miles of creeks, streams, and marsh-line	15
Area surveyed in square miles	4

Hydrographic resurvey of the upper part of New York Bay and of East River to Throg's Neck.—In the last annual report an account was given to the end of June, 1885, of the progress made by the party of Lieut. J. M. Hawley, U. S. N., Assistant Coast and Geodetic Survey, commanding schooner Eagre, in the hydrographic resurvey of Upper New York Bay and the East River to Throg's Neck. At that date the hydrography of a portion of the upper bay had been completed and that of the East River to Brooklyn Bridge.

A plane of reference for the soundings was obtained by means of a self-registering tide-gauge which was put up on Governor's Island, near Castle William, at the beginning of the season, and

maintained in operation till its close. The mean low water for this gauge was found to correspond to that determined by the long series of observations which had in former years been kept up at this point. Comparison gauges were established during the progress of the work at the Navy-Yard, at Bellevue Hospital, and at Astoria, Long Island. Before removing these temporary gauges, sketches were made of the locality where each one was placed, and bench-marks were left.

The work of sounding in so crowded a harbor was attended, as might be supposed, with many difficulties. Two small steam launches, a whale boat, and a dinghy were used. The dinghy was employed in taking soundings in all the slips and around the wharves; this work being assigned to one officer. As a result of this work, many of the slips have since been dredged, the owners finding out from the survey that there was much less water in them than they had supposed.

At times the strength of the tidal current in the river was so great that the launches could not overcome it, and work would have to be suspended until the tide slacked; this was particularly the case in the Blackwell Island Channels. In the month of August many of the crew were prostrated by illness arising from the heat and the unwholesome odors along the East River wharves; hence for about three weeks it was found advisable by the Hydrographic Inspector to send the vessel down to the lower bay to engage in observations of currents. This plan restored all on board to good health.

Between Eighth street, New York, and Blackwell's Island, seven uncharted rocks and shoals were developed, all of which were immediately reported to the office, from which Notices to Mariners were issued, describing their location. The most important of these rocks was one found of about ten feet in diameter, nearly in mid-channel in the East River. It is now marked by a danger buoy. [Notice to Mariners No. 64.]

Lieutenant Hawley acknowledges the faithful and intelligent service rendered by his assistants in the work. The following-named naval officers were attached to the party during the season: Lieut. D. D. V. Stuart, U. S. N., and Ensigns F. H. Sherman, A. W. Dodd, and R. O. Bitler, U. S. N. The statistics of the work from its beginning, May 24, 1885, till its close, November 15, are as follows:

Miles run in sounding	366
Angles measured	9,319
Number of soundings	29,950

In November, Lieutenant Hawley was ordered to relieve Lieut. E. D. F. Heald, U. S. N., of the command of the steamer Bache, and to prepare that vessel for hydrographic work on the Gulf coast. An account of this service will be given under the heading of Sections VII and VIII.

Topographic survey of the shore-lines of the North River, New York; also of shore-lines on Long Island and on Staten Island.—The progress of the topographical surveys of the North River shore-line and of shore-lines on Long Island and Staten Island, New York Harbor, by the party under the charge of Assistant D. B. Wainwright, was briefly recounted in the last annual report.

In order that the hydrographic survey of the North River, which had been begun towards the end of May, 1885, might suffer no delay for want of positions, Mr. Wainwright's first work was to determine, by plane-table triangulation, points on both sides of the river which would be serviceable for hydrographic and topographic surveys. These points having been furnished to Lieutenant Cutler, who had charge of the hydrography of the river, the details of the dock and shore line were completed from the Battery to the New York Central Railroad piers on the New York side, and from Castle Point to the West Shore Railroad property on the New Jersey side. This done, Mr. Wainwright took up and completed a topographic sheet including the shore-lines of North River and Upper New York Bay from the docks of the New Jersey Central Railroad Company to Caven's Point, New Jersey, and Ellis and Bedloe's Islands.

The three projections which included this work and that first named were upon a scale of 1-5000.

The shore-line of Long Island was then delineated from Red Hook to Unionville on Gravesend Bay, and that of Staten Island from the new slip of the Rapid Transit Company to a point southwest of Fort Tompkins. For this work the scale was 1-10000. Shore and marsh line from

Norton's Point, Coney Island, to Unionville were then put in on the Coney Island sheet, scale 1-5000, of Assistant J. Hergesheimer. Tracings of shore-line and positions of points were furnished to the hydrographic parties at work in the vicinity.

Mr. Wainwright calls attention to important changes in topographical details that have taken place since previous surveys. Among those are the new piers, warehouses, ferry-slips, and the large area of reclaimed land belonging to the West Shore Railroad on the New Jersey side of the North River just below the old Weehawken Ferry Landing. Across the river the New York Central Railroad has built five very large new piers, with warehouses and grain elevators. The bulkhead line and the reclamation of the area back of it from Twenty-sixth to Thirtieth streets is still incomplete, owing to legal difficulties.

At the Battery, Pier "New No. 1" has been completed, and pier A nearly so. Both of these piers are constructed of masonry.

The area of reclaimed land, just above Caven's Point, owned by the National Storage Company, and now known as Black Tom's Island, is shown on Assistant Whiting's survey of 1875. Since then it has been connected with the main land by a railway on trestle work, and a large, irregularly-shaped warehouse built upon it. At the time of Mr. Wainwright's survey, additions to the island were in progress; part of these are shown on the plane-table sheet. The company was engaged also in dredging a channel to deep water. On Bedloe's Island the pedestal of Bartholdi's Statue of Liberty was accurately determined in position.

On Staten Island the Rapid Transit Company has built a new slip, and connected it by a new piece of railway, mostly along the water front, with the former terminus of the road at Stapleton. This road will be continued along the north shore, and it is over this route that the Baltimore and Ohio Railroad Company expects to get an entrance to New York.

Assistant Wainwright expresses his obligations to Assistant E. Hergesheimer for advice in regard to many details of the work, and for his uniform readiness to give him the benefit of his large experience. Mr. James A. French served as rodsman in the party, but his familiarity with the work and the skill he had acquired in it made his position rather that of an aid.

Field operations were closed early in November, and the following statistics were reported:

Miles of shore and dock-line surveyed—	
On the upper sheet, North River	22
On the lower sheet, North River	42
On the New Jersey shore of the Upper Bay	9
On Long and Staten Islands	35
Miles of shore-line added to Coney Island sheet	15
Total number of miles of shore and dock line	123

In May, 1886, Mr. Wainwright was directed to resume his topographial work in the vicinitye of New York, and on the 1st of June organized a party for the resurvey of the shore-line of the Harlem River from Randall's Island to Spuyten Duyvil Creek, and of the Hudson River from that creek to the New York Central Railroad docks.

At the date at which this report closes he was actively engaged in the prosecution of this survey.

During the winter of 1885-'86 Mr. Wainwright was assigned to service on the coast of North Carolina. Reference to this is made under the heading of Section IV in this report.

Hydrographic resurvey of the North River and of Upper New York Bay, New York.—Mention was made in the last annual report of the progress of that part of the hydrographic resurvey of New York Bay and Harbor included in the North River and its approaches. This work, begun in May, 1885, was prosecuted by the party in charge of Lieut. W. G. Cutler, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner Palinurus, until November 20 of that year.

Lieutenant Cutler's work was laid out on four projections, each on a scale of 1-5000, and covering the following areas: On the North River, from Castle Garden to Castle Point, from Castle Point to Bull's Ferry, and from Bull's Ferry to Fort Lee; in New York Upper Bay from Kill van

Kull to Red Hook. All of the work on these hydrographic sheets was completed, with the exception of that on the upper sheet of the Hudson, ending at Fort Lee; about two-thirds of this was finished.

The soundings were referred to the plane of mean low water at Governor's Island.

On two days in August, the 10th and 28th, stations off the entrance to the harbor were occupied for observations of currents.

Lieutenant Cutler found no new obstacles to navigation in the course of his survey.

Ensigns E. E. Wright and A. G. Rogers, U. S. N., were attached to the Palinurus.

The statistics of the season's work are:

Miles run in sounding	471
Angles measured	5, 006
Number of soundings	26, 625

Special hydrography for the determination of tidal levels in the Hudson, Harlem, and East Rivers, and in Flushing, Little Neck, and Newark Bays.—In order to obtain data for aiding in the investigation of the laws of tidal action in the Hudson, Harlem, and East Rivers, and in Flushing, Little Neck, and Newark Bays, Lieut. C. P. Perkins, U. S. N., Assistant Coast and Geodetic Survey, in pursuance of detailed instructions from the Hydrographic Inspector, organized his party on board the schooner Eagre in May, 1886.

At the date at which this report closes, Lieutenant Perkins was actively engaged in prosecuting this special survey, and had completed the soundings upon the Hudson River from One hundred and twenty-fifth street to King's Bridge, referring them to the mean low water of a tide-gauge at the dock at One hundred and fifty-fifth street. Further mention of his work will be made in the next Annual Report.

Ensigns W. B. Sears, W. B. Fletcher, and C. S. Williams, U. S. N., were attached to the Eagre.

Magnetic observations at stations in New York, New Jersey, Pennsylvania, Delaware, Maryland, and at Detroit, Mich., and Washington, D. C.—Determinations of the magnetic declination, dip, and intensity being needed at a number of stations to obtain further material for the study of the laws of change in the magnetic elements, Subassistant James B. Baylor was directed to take up that work under instructions bearing date of July 14, 1885. As far as practicable he was to reoccupy stations at which these elements or one or two of them had been previously determined.

At New York City the station of 1846 at the Manhattanville Asylum could not be re-occupied, and a new one was selected in Riverside Park near the extension of One hundred and twenty-sixth street. At this station, as at all others occupied by Mr. Baylor on this tour, with the exception of Washington, D. C., observations were made for values of the magnetic declination, dip, and intensity.

At Buffalo, N. Y., a station was selected in the grounds of Fort Porter, one hundred and seventy-nine feet from the Lake Survey Station of 1873. The formation is pure limestone.

At Oxford, N. Y., the Bache Fund Station of 1874 was re-occupied. At Sandy Hook, N. J., the point occupied was within a few inches of the stations of 1873 and 1879. The station at Cape Henlopen, Delaware, was seven hundred and nine feet in a northwesterly direction from the Light-House and on the same side of it as the station of 1856, though not identical with it on account of the shifting sand formation.

At Baltimore, Md., the same station, within the limits of Fort McHenry, was occupied as in 1877.

At Washington, at Assistant Schott's observatory on Capitol Hill, observations were made with the dip circle, before and after the season's work, to determine the intensity by the Lloyd method at the several stations occupied.

At Harrisburg, Pa., the station occupied was the same as that at which magnetic observations were made in 1877 in the grounds of the State capitol. A station near Pittsburgh, Pa., was selected in a large open lot north of the Allegheny observatory, and at a distance of one hundred and seventy-one feet seven inches due north from the center of the transit instrument. The soil

is a black loam. The station at Erie, Pa., was in the grounds of the Marine Hospital; and that at Detroit, Mich., in the spacious grounds in the rear of the Harper Hospital.

In closing his report, Mr. Baylor expresses his belief that the establishment at State capitals and principal county seats, of standard meridian lines and the determination of the magnetic variation from time to time, would be an undertaking of great practical utility, and that its results would be highly appreciated by property owners, by surveyors, and by all persons interested in the accurate laying out of land boundaries.

After devoting some time to the completion of the records and computations of his work for the archives Mr. Baylor received orders for duty on the Southern coast, reference to which will be made under the heading of Sections V and VIII.

Physical hydrography—New York Harbor survey—An epitome of results for tidal flowage through New York Harbor—Progress of other investigations noticed.—Assistant Henry Mitchell has submitted a project for continuing the physical hydrography of New York Harbor, based upon the results of his work of 1885. This work was suspended, under instructions, in September of that year. It had, however, made sufficient progress to enable Mr. Mitchell to discuss the following subjects: (1) The flood and ebb discharges of the Hudson River, East River, Kills, and Narrows, reduced to the same mean range of tide; (2) how far up the Hudson River does the effective tide of the river extend; (3) what new observations are necessary to determine the laws of movement of the tides and currents in East River; (4) the Kill van Kull and its relation to New York Harbor; (5) the formation of New York Bar.

Upon these several points the suggestions outlined in Mr. Mitchell's report will be of value in the further prosecution of the work.

With regard to the tidal flowage through New York Harbor, the following results are submitted:

Epitome of results for discharge, June 25, 1886.

	Cubic feet.
East River (Nineteenth street):	
Ebb (westerly)	4,454,937,257
Flood (easterly)	4,007,175,676
Excess of ebb	447,761,581
Hudson River (Thirty-ninth street):	
Ebb (southerly)	6,996,678,413
Flood (northerly)	6,225,985,545
Excess of ebb	770,692,868
Kill van Kull (West New Brighton):	
Ebb	1,790,103,372
Flood	1,712,415,362
Excess of ebb (towards the harbor)	77,688,010
Narrows:	
Ebb (seaward)	13,819,895,144
Flood	12,703,616,481
Excess of ebb	1,116,278,663

Other sections concur remarkably well with these, which are selected as the best.

The fresh-water discharge of the Hudson River at Thirty-ninth street was found, August 11 and 12, 1865, to be 385,346,424 cubic feet, and the fresh-water discharge at Dobbs' Ferry, August 19–21, was found to be 373,426,507. These results differ about 2½ per cent. which must cover not only errors of observation but difference of declining land waters.

After the above epitome of results had been prepared, it occurred to Mr. Mitchell to compare them with the gauging of East River at Wall street as given in his report entitled "The Harbor of New York. Its condition May, 1873" (Appendix No. 8, Annual Report of Superintendent, 1871). Table 15 of that report gives—

	Cubic feet.
Mean ebb and flood at Wall street, 1873	4,362,300,000
And we have at Nineteenth street, 1886, mean of ebb and flood	4,231,056,466

Considering that these results were reached several years apart, by very different persons and means, the agreement is very remarkable.

With regard to New York Bar, Mr. Mitchell observes that over it passes nearly all the discharge gauged at the Narrows added to the tidal prism of the Lower Bay. Quoting his own words following:

"I say *nearly all*, because there are indications that Raritan Bay is in some degree filled and drained by way of the Narrows,—in what degree we must compute from observations grouped by lunar hours, as it is impracticable to make so large a series of simultaneous gauging as should absolutely determine the matter directly.

"Of course it is not the identical water passing over the bar that we observe to be in motion elsewhere, but its equivalent. A single particle makes an elliptical journey, an orbit of a few miles major axis.

"One may easily see that if the depth were a direct function of the velocity of the current it would vary from spring tides to neaps, which it is not observed to do. It is believed then that the resultant for the tidal day represents the net scouring force irrespective of tidal range or volume.

"By working up the *resultants* we determine to what extent the motion of a grain of sand is tending towards some vortex, and this is the way in which we propose by multiplication of stations to show the method of bar-building, and why it is arrested at a certain stage of development."

Mr. Mitchell will present the results of the work of his party in New York Harbor and its approaches in a more complete form at a later date. The observations were made, under his supervision, by Assistant H. L. Marindin, with the aid of Assistant Marcus Baker and Lieut. F. S. Carter, U. S. N.

Physical hydrography, New York Bay and Harbor.—Reference was made in the last annual report to instructions issued to Assistant H. L. Marindin at the opening of the season in 1885, directing him to organize a party with such subdivisions as might be advised by Assistant Mitchell for the development of the physical hydrography of New York Bay and Harbor. Mr. Marindin has submitted a detailed report of the operations under his own immediate direction, an abstract of which is here given.

Two parties were provided for, one on board the schooner Scoresby, in charge of Mr. Marindin, the other on board the schooner Drift, under command of Lieut. F. S. Carter, U. S. N., working in co-operation with the Scoresby. From July 1 to 13 the two vessels with the steam launches attached remained at the New York navy-yard to complete their fitting up, a new arrangement of reels and connections being required to obtain the velocity of currents at all depths by means of electric current meters and registers.

On July 13 the steamer Daisy, with Commander C. M. Chester, U. S. N., Hydrographic Inspector, on board, towed the vessels to their first station in Kill van Kull.

In order to rate the electric meters before beginning observations of currents, one of the Scoresby's boats was transported inland into a still-water pond. With the different meters attached, the boat was then run over an accurately-measured base-line, and this operation was repeated at a different speed. In this way a good rating was obtained for the four electric meters.

The vessels were then brought on to a cross-section of the Kill van Kull, and observations were begun by erecting the range signals, sounding the cross-sections, and observing the velocities of the stream during several ebbs and floods with the Price electric-current meters.

Tidal observations were in progress at the same time at Elbow Beacon, at the head of Newark Bay, at Elm Park, at the foot of the bay, and at both of the cross-sections in the Kills. The self-registering tide-gauges at Sandy Hook, at Governor's Island, and at Willet's Point, East River,

were also kept in operation; the two first named by observers under Mr. Marindin's immediate direction. At Willet's Point Captain Knight, of the United States Engineers, kindly offered to detail an orderly to keep the gauge going. This offer was accepted, and the records were forwarded to Washington.

By the 5th of August the observations in the Kills were completed, and the parties were transferred to the Hudson River, off Thirty-ninth street, where a discharge section was observed in connection with simultaneous observations in the East River, where the Drift had been sent. It had also been arranged that the naval parties on the steamers Endeavor and Daisy and schooners Eagre and Palinurus were to undertake some current observations on Sandy Hook Bar simultaneously with the Scoresby and Drift in the Hudson and East River respectively. This was done, and the records were forwarded to the office.

August 14 Mr. Marindin moved his party to Dobb's Ferry, on the Hudson, and was joined by the Drift. Observations were then begun for obtaining the discharge of the Hudson River. Tidal observations were kept up at Dobb's Ferry Wharf, near one end of the cross-section; tide-stations were established also at Iona Island, at Sing Sing, at Forty-second street, Hudson River, at Pot Cove, in the East River, and at Old Ferry Point.

On the 10th of September the party moved from Dobb's Ferry to the New York Narrows, where a cross-section for discharge of ebb and flood was observed. This done, and the electric-current meters again rated at the Kill van Kull, field operations were closed for the season, and early in October Mr. Marindin took up at the office in Washington the computations of his work under the direction of Assistant Mitchell, who had visited the parties several times during the progress of the observations.

Mr. Marindin had the efficient aid of Assistant Marcus Baker, and also that of Mr. Homer P. Ritter, of the Mississippi River Commission, an expert in current observations and river gauging. Messrs. W. N. King and J. De Wolf were also attached to his party.

Duty assigned to Mr. Marindin in connection with surveys of the Delaware River above Philadelphia is referred to later under a heading in this section.

Topographic resurvey of the shore-lines of Coney Island, Barren Island, and Rockaway Beach, New York Lower Bay.—Reference was made in the last annual report to the beginning of the topographical resurvey of the shore-lines of Coney Island, Barren Island, and Rockaway Beach by the party under charge of Assistant Joseph Hergesheimer. This work, begun June 18, 1885, was completed early in September of that year. It included, on a scale of 1–5000, the south side of Coney Island, with all of the adjacent topography, the entrance into Sheepshead Bay, with the adjacent shoals, the changes on Barren Island, the islands and shoals in Rockaway Inlet, and Rockaway Beach from its western end for a distance of about four miles to the eastward.

Marked changes were found in the topography since the surveys of 1877 and 1878.

The statistics are:

Miles of shore-line surveyed	77
Miles of road surveyed	5
Miles of railroad surveyed	5
Area surveyed in square miles	6

During the winter Mr. Hergesheimer was assigned to duty on the Florida coast. An account of this service will appear under the heading of Section VI.

Tertiary triangulation of Arthur Kill, New York Bay.—In connection with the resurvey of the New York Bay and Harbor, it became desirable to determine trigonometrically a number of points on the shores of Arthur Kill. This work was assigned to Assistant R. E. Halter towards the close of July, 1885. Starting from the line Bergen Church–Elizabethtown Church, a tertiary triangulation was carried down the Kill as far as Boynton's Chimney, just below the town of Woodbridge. Field operations were closed October 8.

The statistics are:

Number of stations occupied	12
Number of points determined	21
Number of sets of observations	435
Number of single observations	5,220

After completing the records and computations of this work Mr. Halter proceeded, under instructions, to Point Isabel, Texas, in December. His duty there will be referred to under the heading of Section IX.

Topographical resurvey of the shore-lines of Bergen Neck, Newark Bay, Sandy Hook, &c., New York Bay and Harbor.—A resurvey of the shore-line of Sandy Hook was completed soon after the beginning of the fiscal year by Mr. E. L. Taney, Aid in the Survey. Reference to this work and to the considerations which led to it as an essential part of the New York Harbor resurvey was made in the last annual report.

After finishing the resurvey of the Hook, Mr. Taney proceeded, under instructions dated July 30, to Bergen Neck, New Jersey, and began a shore-line survey of the Neck at Caven's Point, carrying it from that point to and through the Kill van Kull into Newark Bay to a point about half a mile north of the bridge of the New Jersey Central Railroad. Also along the northern shore of Staten Island through Kill van Kull to Arthur Kill, and along the west shore of Newark Bay from Elizabethport to about half a mile north of the railroad bridge.

The work at Sandy Hook was mostly simple shore-line, but on Bergen Neck and the Kill van Kull it was principally wharf-line, and in this there was considerable detail, a margin being mapped of from a quarter to a half a mile in width.

Field operations were closed October 24. The number of miles of shore and wharf line run was about sixty.

In furtherance of instructions issued for the closing of the suboffice at New York, Mr. Taney was directed towards the end of October to make an inventory of all property of the Survey stored at that office, and to receipt for it to Capt. F. J. Palmer. This done, and arrangements having been made for its transportation to Washington, Mr. Taney was directed to relieve the tidal observer at Sandy Hook from the charge of the self-registering tide-gauge at that station, and to forward the instrument to Washington. Subsequently he received orders to prepare for work on the Gulf coast, and at the end of November left Washington for New Orleans. Reference to his field service in that locality will be made under the heading of Section VIII.

Tidal observations with self-registering tide-gauges at Governor's Island, New York Harbor, and at Sandy Hook, New York Entrance.—The self-registering tide-gauge established in the spring of 1885 at Governor's Island, New York Harbor, was continued in charge of the officers directing the hydrographic parties engaged in the resurvey of the harbor till the close of field operations at the beginning of November.

The self-registering tide-gauge at Sandy Hook, New Jersey, which had been in charge, successively, of Messrs. J. W. Corbett and A. J. Brennan, under the direction of the hydrographic officers of the Survey, was situated on the wharf of the Southern Railroad of New Jersey. This location having been found to be unfavorable, the station was discontinued early in November, 1885. In June, 1886, Assistant Gershom Bradford was directed to proceed to Sandy Hook and make examinations to determine a suitable place for the erection of a permanent automatic tide-gauge. He selected a locality comparatively free from the effects of drifting ice and heavy seas. Here a substantial independent structure was begun, upon which, as soon as possible, a self-registering gauge will be established.

Topographical resurvey of the shore-line of Staten Island from Stapleton southwestward.—In continuation of the resurvey of New York Bay and Harbor, Assistant R. M. Bache took the field, under instructions, in the earlier part of June, 1886, having organized his party for a shore-line survey of Staten Island from Stapleton to the south and southwest, towards Princess Bay and Ward's Point.

Between June 12 and the close of the fiscal year the topography executed was represented by the following statistics, the scale of the projection being 1–10000.

Miles of shore-line surveyed	4
Miles of shore-line of creeks	8
Miles of roads	5
Area surveyed in square miles	1

Mention will be made of the further progress of this work in the next annual report.

Other duty assigned to Mr. Bache during the fiscal year is reported under a later heading in this section.

Hydrographic resurvey of New York Lower Bay and Entrance.—Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Endeavor, has submitted a full report of the hydrographic resurvey of New York Lower Bay and Entrance executed by the party under his charge during the season of 1885. The area covered by this survey included the lower bay from the Narrows to Sandy Hook, and the work was laid out on four hydrographic sheets, each on a scale of 1–10000.

Soundings were begun June 2, at which date the necessary signals had been established, and continued till early in November, when the work, in its most essential parts, was completed. Throughout the season Lieutenant Hanus had the aid of a steam launch, and on July 13 the steamer Daisy was added to the party equipment, and was found to be exceedingly useful, though not so economical as the Endeavor, owing to her small coal capacity. To do successful work on the scale of the hydrography, in a strong and constantly varying tidal current, was attended with many difficulties in a harbor so full of passing vessels, some of which were often getting in the way. When the rate of speed was changed, the drift due to tide varied, and the lines of soundings being so close, a slight drift would carry the steamer from one line to the other.

In developing the work many lines were run to the northward and westward of Romer Beacon, so as to make sure of the amount of water that can be carried across the shoal, since much time can be saved to all the smaller vessels by cutting across this shoal instead of following the Swash Channel. Special care was taken to develop thoroughly all the channels, notably that of Coney Island, since it is the shortest route to the sea.

To obtain a plane of reference for the soundings, a tide-gauge was established on the steamboat wharf at Bath, Gravesend Bay, Long Island. This gauge, as well as all the work in connection with tidal data, was placed under the personal supervision of Ensign G. R. French, U. S. N., whose extensive experience with tide-gauges on various parts of the coast gave Lieutenant Hanus great confidence in his good judgment and the accuracy of his results. It was deemed desirable to have the reference gauge directly under the control of the party, and it was found by comparison that high water occurs at Bath about ten minutes later than at Sandy Hook, and that the mean rise and fall at both places is about equal, namely 4.8 feet. The usual bench-marks were established, and descriptions of them placed in the record books.

On Saturday, August 8, preparations were made for current observations, and on the 11th the steamer Endeavor towed the schooner Palinurus, and the steamer Daisy the schooner Eagre into position, forming a circle from Rockaway Inlet to the Navesink Lights. A party was also sent from the Endeavor to the wreck of Scotland Light Ship, and a series of simultaneous observations was taken. On August 18 observations with current chips were taken by both the steamers Endeavor and Daisy. The chips were followed during one whole flood and part of the succeeding ebb tide.

On August 27 the Endeavor and Daisy, as well as the schooners Palinurus and Eagre, proceeded to stations previously designated in the lower bay. Two sets of simultaneous observations of currents on different stations were taken, and on the 30th the vessels returned to Bath. All of the results obtained in current work were transmitted to Assistant Henry Mitchell, chief of the party engaged in the study of the physical hydrography of New York Bay and Harbor.

Lieutenant Hanus's device for hydrographic signals, known as pump-signals, and described on page 34 of the annual report for 1883, was found to be very effective. Long and slim trees were used, from sixty to seventy-five feet in length; these were planted with ease in from two to three and a half fathoms of water. Some of these signals were at least thirty-five feet out of water, and out of twelve planted but one was carried away during the season.

Box tide-gauges, which would otherwise be difficult to secure in exposed places, can be readily fixed in the same way, or can be at once attached to one of these signals.

The following-named naval officers aided in the hydrographic work: On the Endeavor Ensigns C. S. Ripley, E. F. Leiper, F. R. Brainard, and G. R. French, U. S. N.; on the Daisy, Ensigns J. M. Elliott and B. E. Thurston, U. S. N.

Lieutenant Hanus reports statistics as follows:

Miles run in sounding	1,755
Angles measured	20,545
Number of soundings	90,086

In November Lieutenant Hanus received instructions to fit the Endeavor for work on the coast of South Carolina. A report of this service will appear under the heading of Section V.

In June, 1886, he took up the hydrography in New York Bay and vicinity from the limits of the season of 1885, and by the end of the fiscal year had carried the work over Sandy Hook Bay and part of Raritan Bay. For that month the statistics reported are as follows:

Miles run in sounding	169
Angles measured	1,543
Number of soundings	7,849

Determinations of gravity and pendulum experiments.—The plan for carrying on gravitation work during the fiscal year 1885–1886 was outlined in instructions received by Assistant Charles S. Peirce in July, 1885. He was directed to make a reconnaissance for an east and west line of stations along or in the vicinity of the forty-third parallel of north latitude as far west as the Mississippi River, examining certain specified localities with reference to their facilities for gravitation stations, and then occupying such stations, three or four in number, as should best fulfill the conditions required.

After careful examinations the stations finally selected were Ann Arbor, Mich., Madison, Wis., and Ithaca, N. Y. At these stations, and at the Smithsonian Institution, Washington, the invariable reversible pendulums Peirce No. 2 (a meter in length) and No. 3 (a yard in length) were remeasured and were oscillated. The rule was to oscillate each pendulum eight times in each position on each stand.

Two new pendulum stands had been constructed of improved design, so that two pendulums could be oscillated simultaneously on two supports. Each swinging consisted of five thousand oscillations with heavy end up and fifteen thousand with heavy end down, except that one-fourth of the swingings in the latter position were of double length. There were thus about six hundred thousand oscillations with heavy end down and one hundred and sixty thousand with heavy end up at each station.

At Ithaca one of the stands was set up in a cold room, so that the average temperature was about 0° Centigrade, while that of the other was about 15° Centigrade.

The three Kater invariable pendulums used by Colonel Herschel, and later by Assistant Edwin Smith, were, at the request of Professor Stokes, the president of the Royal Society, oscillated in Hoboken preparatory to being returned.

Special experiments were made in Ithaca on the variation of the absolute personal equation in observations of pendulum transits with the amplitude of the vibration. These experiments were fully reduced.

The reductions of the observations at Ann Arbor and Ithaca were carried toward completion, and those of observations made at Madison and Washington were begun. A reduction was also begun of observations made at Key West in a former year.

At Washington, Ann Arbor, and Madison time signals were kindly supplied by the Directors of the Observatories of those cities. At Ithaca and Hoboken time was observed by Mr. Peirce.

Continuation of the primary triangulation in the eastern part of the State of Pennsylvania.—Prof. Mansfield Merriman, Acting Assistant, under instructions dated June 22, 1885, began immediately the erection of signals and preparations for the occupation of stations for the extension of the primary triangulation in the eastern part of the State of Pennsylvania. The plan of his work involved the occupation of a number of stations to the east and west of a line between Allentown, Lehigh County, and Wilkes Barre, Luzerne County.

Knob Station, near Mauch Chunk, Carbon County, was first occupied. Signals were erected at two stations and heliotropers posted at five. Horizontal angles were measured between these stations and directions to eight secondary points were observed. The work at Knob was finished July 18, and two days later Professor Merriman began the occupation of station Bear's Head,

about thirteen miles northwest of Pottsville, Schuylkill County. From Bear's Head, angles were measured between five primary stations, at three of which heliotropers had been posted, and directions were observed to six secondary points.

Upon the completion of this station, July 31, the party was transferred to Pimple Hill, a station about eighteen miles northeast of Mauch Chunk, and on the completion of observations at that point, August 15, to Smith's Gap, about fourteen miles north (nearly) from Allentown. The occupation of two more stations, Bake Oven, about eighteen miles northwest of Allentown, and Port Clinton, fourteen miles in a southeasterly direction from Pottsville, finished on September 15 the work of the season.

Occasion was taken to determine secondary points, such as spires, towers, &c., at every favorable opportunity.

All of the records of the work, original and duplicate, were forwarded to the office with the computations in October. Statistics of the season are as follows:

Number of stations occupied	6
Number of primary directions observed	30
Number of secondary directions observed	23
Number of measures of primary angles	2,812
Number of measures of secondary angles	720

Reconnaissance for the extension of the triangulation in the eastern and northeastern parts of the State of Pennsylvania towards the boundary between Pennsylvania and New York.—An account of the general plan of the reconnaissance in Eastern Pennsylvania, intrusted to the charge of Assistant O. H. Tittmann, was given in the last annual report. After consultation with Prof. Mansfield Merriman, Acting Assistant, who had direction of the primary triangulation in that part of the State, Mr. Tittmann accompanied him in the latter part of June to stations Pimple Hill and Penobscot, which he had before selected, in order to determine the intervisibility of these and other points. Through Professor Merriman's hearty co-operation he was enabled to start from these two points as a base and to carry the reconnaissance northwardly towards the boundary.

Mr. John E. McGrath served as Aid in the party, and to him was assigned the duty of measuring angles at the stations selected by Mr. Tittmann along the edge of the northern coal-field, in pursuance of a request made by the State Geological Survey.

Field-work was closed October 5, the reconnaissance having been carried to the State boundary, and a connection outlined with the New York State Survey on the line Windsor–Warren.

During the winter Mr. Tittmann was assigned to duty which will be referred to under the heading of Section VIII.

Reconnaissance for triangulation in the southern and western part of the State of Pennsylvania.—The plan of work which had been committed to the charge of Prof. L. H. Barnard, Acting Assistant, about the beginning of the fiscal year, involved the occupation of a number of stations in the southern and southwestern part of the State of Pennsylvania as soon as the reconnaissance should have been sufficiently developed. Events which occurred in July, 1885, affecting the management of the Survey, led to delay in forwarding instruments to Professor Barnard, so that he was unable to do any effective work before August 1. Unfavorable weather then set in and prevented the measurement of any angles except those at station Dauphin, about seven miles north (nearly) from Harrisburg.

Observations were made at station Dauphin on three stations, Mexico, Doubling Gap, and Piney Mountain (South Mountain) at distances respectively of twenty-seven, twenty-four, and thirty-nine miles to the northwestward, westward, and southwestward. A tripod was set up at station Clark's Knob, about twenty miles to the northwest of Chambersburg, Franklin County, and a rapid reconnaissance was made to the north and west of this station.

Professor Barnard was engaged in prosecuting his reconnaissance in Adams County, between Gettysburg and Chambersburg, when he received orders to close field operations on or about October 1. Mr. John Nelson served very effectively as Aid in the work.

In May, 1886, instructions were given to Professor Barnard to resume his reconnaissance at as

early a date as the funds available would permit, and extend it westward to the Allegheny Mountains and southward to the State boundary.

Completion of the survey of the parallel boundary between the States of Pennsylvania and West Virginia.—In the annual report for the fiscal year ending June 30, 1884, an account was given of the beginning of a survey of the boundary line between Pennsylvania and West Virginia, which follows nearly the parallel of 39° 43′.3 for a distance of about fifty-five miles from the southwestern corner of Pennsylvania to the Maryland corner. This work was undertaken at the request of the Joint Commission of the two States, and was placed in charge of Assistant C. H. Sinclair, who was aided in 1883 by Assistant C. H. Van Orden. Three sections of the boundary had been traced out for a total distance of thirty-five miles and eight-tenths, when it became necessary to suspend field operations.

In September, 1885, Mr. Sinclair was instructed to resume this survey and push it to completion. Having met the Commissioners at Point Marion, Pa., he began operations near that place by determining an azimuth so as to start a tangent in the prime vertical of the initial point as a reference line for the old marks on the parallel of latitude laid down by Mason and Dixon in the years 1763–1767. By September 24 all needed computations had been made and the party having been fully organized, the work of ranging out the tangent began. The country was wooded and the line had to be opened; there was also much rainy weather, but despite all delays the ranging out was completed for the entire tangent, a distance of more than nineteen miles, by the 8th of October.

For the measurement of the line a small triangulation was laid out. In addition to this about fifteen miles of the second and third tangents which had been ranged out in 1883 were reviewed to see that the pegs set in that year to mark the places for the new monuments were still in place. All of the pegs needed for the new stones on the fourth or last tangent were set by the 26th of October. On this last tangent were found eighteen of the marks or mounds left by Mason and Dixon, and no changes were made in the boundary, as it had been decided by the Commissioners that the old line was to be reproduced and marked. The mounds recovered were as a rule on the ridges, and most of them were in a fair state of preservation. Many had been destroyed or lost, particularly those mile-marks that happened to fall on the hill-sides or in ravines. No attempt was made to restore the old mile-marks, but the new stone monuments were set in most cases so as to be intervisible.

Four maps were made, two for each State, on a scale of 1–40000, showing how the survey was conducted and the position of the monuments, which are of cut sandstone. These maps and a report of the survey in duplicate have been sent to the chairman of the Joint Commission. Tracings of the maps and a copy of the report have been deposited in the archives of the Coast and Geodetic Survey.

In April, 1886, Mr. Sinclair proceeded, under instructions, accompanied by members of the Commission, to set a large stone monument to mark the point of junction of the three States, Pennsylvania, West Virginia, and Maryland. This duty accomplished, he returned to the office.

In closing his report Mr. Sinclair suggests that in view of the number of State boundaries to be resurveyed, remarked, and in many cases corrected, it might be advisable to obtain from Congress a special act authorizing the Superintendent to undertake the rectification of these boundaries when applied to by the Commissioners of the States interested.

Other duty assigned to Mr. Sinclair during the fiscal year in Sections III, XV, and XVI will be referred to under the headings of those sections.

Physical hydrography of the Delaware River above Petty's Island.—Having been authorized to continue his relations to the Harbor Commissioners of the port of Philadelphia as Secretary of the United States Advisory Board, Assistant H. L. Marindin attended a meeting of the Board in Philadelphia, October 20 to 22, where he prepared a description of the location of turning points in the Port Warden lines of the city as recommended by the Advisory Board. Returning to Washington, he resumed his office-work, and remained there on duty till the middle of April, 1886, when he was instructed to proceed to Philadelphia and organize a party to continue the physical hydrography of the Delaware River above Petty's Island. Upon the arrival of the schooner Ready in

the river, early in May, field-work was begun. The following are the statistics of progress reported at the close of the fiscal year:

Number of cross-sections observed for currents	48
Number of current observations	3,401
Number of soundings	1,695
Number of tide-stations occupied	5

Mr. Marindin acknowledges valuable assistance rendered by Messrs. Homer P. Ritter, Neville B. Craig, and G. E. Kent, who were employed specially for this service.

Physical hydrography—Observations of the formation and movement of ice in the Delaware River.—During the winters of 1878–1879 and 1884–1885, studies of the formation and movement of ice in the Delaware River were made part of the duty of Assistant S. C. McCorkle. In January, 1886, Mr. McCorkle was directed to resume these studies. In addition to his own personal observations he made arrangements for observations of temperature, the weather, and the movement of ice by the keepers of eleven lights between the Horseshoe and the Breakwater during the months of January, February, and March. Capt. George B. White, U. S. N., Light-House Inspector of the Fourth District, kindly exerted himself to obtain the necessary orders from the Light-House Board. Thermometers were sent to the light-keepers, and reports were received from all of them except from the Fourteen-feet Bank Light-ship, which was removed from her station on account of the ice soon after observations were begun.

The co-operation of the captains of the Winsor line of steamers, of the Philadelphia and Reading Railroad steam colliers and of the trustees of the city ice-boats was also obtained.

The severest cold of the winter occurred between January 10 and March 2. On the night of January 10 the river was frozen over from Philadelphia to Billingsport, about ten miles below the city, and the ice continued solid or nearly so in the coves and on the shoals till February 14, the channels being opened by the ice-boats.

Mr. McCorkle remarks that steam-power is the solvent of the ice problem, and will continue to be so till the improvements now projected or in progress shall have been completed. Beginning with the head of Petty's Island, his observations went to show that the dike built last autumn from Fisher's Point towards that island had the effect of causing a greater volume of water to flow through the western or Philadelphia channel, and that by reason of this the river from Five-Mile Point down has been less obstructed by ice than at any time within his knowledge. Owing partly to this, and partly to the constant trips of the four lines of powerful ferry-boats which ply to and from the Jersey shore, the river in front of the city has been less obstructed by ice than usual.

Extremely low tides were noticed as prevalent during the winter; these were partly caused by the prevailing northerly and westerly winds, but in Mr. McCorkle's opinion there was another cause. In many parts of the river the ice was solid during the whole period from January 10 to February 14. Much of the floating ice would lodge under this, and a contraction of the tidal area would be the result, the volume of the flood tide being much lessened. He believes, therefore, that during a partial blockade of the river by ice a much less quantity of water was drawn by the tide from the sea than ordinarily, and he suggests the importance of tidal observations during a season of ice.

Mr. McCorkle's elaborate report of his observations and conclusions is accompanied by a number of appendices embodying the reports of the observers whom he employed to co-operate with him, and forms a contribution of value to our knowledge of what is still at times, although but for brief periods, an obstruction to navigation in an important highway of commerce.

Special survey of the Schuylkill River between Gray's Ferry and Rambo Point.—In compliance with a request from Mr. W. R. Tucker, chairman of the Port Warden's Committee of Philadelphia, Mr. Charles Junken was directed early in July, 1885, to organize a party to make a detailed survey of that part of the Schuylkill River between Gray's Ferry and Rambo Point.

From the geodetic stations "Schuylkill Arsenal" and "Eastwick Tower" as a base, he determined by triangulation the new stations required for his survey. On the 11th of July he began a plane-table survey of the shore-line, and a few days later commenced to take soundings. For these a plane of reference was obtained from a tide-gauge fixed on Bulkley's Wharf, comparisons

being made with a bench-mark established by the United States Engineers on the south face of the west abutment of Gray's Ferry Bridge. Mean low water was thus determined without continuing observations during an entire lunar period.

Field-work was closed and the party disbanded July 17. Mr. Junken then returned to Washington and prepared tracings of his survey for the use of the Port Warden's Committee.

The statistics are:

Number of horizontal angles measured	6
Length in miles of shore and wharf line surveyed	1
Number of soundings	660
Miles run of sounding lines	5

Mr. Charles A. Junken served efficiently as recorder in the party.

Geodetic operations—Continuation of the triangulation and reconnaissance of the southern part of the State of New Jersey.—At the beginning of the fiscal year Prof. E. A. Bowser, Acting Assistant, had resumed field-work, in accordance with instructions, for the extension of the triangulation and reconnaissance in Southern New Jersey from the limits of his work of the previous season. The country being flat and thickly wooded with pine and cedar, the first work of the party was to build observing tripods and scaffolds at Stations Hammonton, Blangie, and Martha, so as to render these points intervisible. The two stations first named are in Atlantic County, and required tripods forty-three and one-half feet high. At Station Martha, about nine miles northwest of Tuckerton, Burlington County, the tripod was fourteen feet in height. Observations at this point were begun July 8, signals having been erected at Apple Pie Hill and Ridgway in addition to those at Blangie and Hammonton. A number of tertiary points were also observed upon.

Care was taken by Professor Bowser to mark his station points securely. Granite posts, four and one-half feet long and dressed to six inches square for six inches from the top, were set in hydraulic cement at each of the observing stations. The letters "U. S." were cut into each of the four faces of the posts, and upon top an equilateral triangle having sides three and one-half inches in length.

Station Martha was marked in this way July 29, and on the 31st the party moved to Station Blangie, in Atlantic County, about two and one-half miles northeast of May's Landing, on Great Egg Harbor River. At this station observations were completed September 22, and the party was transferred to Station Hammonton in the vicinity of the town of the same name in Atlantic County. At this point observations for the season were closed November 5, though all of the measurements desired had not been obtained, the weather becoming unfavorable, and experience having shown the inutility of attempting to continue horizontal angle observations later than November first in New Jersey.

On the 9th of November Professor Bowser resumed the reconnaissance from the line Kellogg–Russia where he had left it in November, 1884, and carried it westward and southward towards Bridgeton and Mauricetown. The reconnaissance was attended with difficulties on account of a high ridge, covered with tall pines which ran northwesterly and southeasterly along Maurice River, and intercepted the view of signals as much as from seventy to ninety feet in height. Search was made, but without success, for two stations of the primary triangulation of 1845, Joscelyne and Pine. Finally, however, three additional points were selected, and the reconnaissance was closed on the line Bridgeton–Fairton.

During the season one hundred thirty-nine sets of observations were taken upon primary stations and fifty-four sets upon secondary or tertiary points.

Towards the 1st of June, 1886, Professor Bowser was instructed to resume the reconnaissance, as recommended in his report, westerly from the line Kellogg–Newfield.

Continuation of the topographical resurvey of the coast of New Jersey.—Reference was made in the last annual report to the operations of the party of Assistant Charles M. Bache, engaged at the beginning of the fiscal year in continuing the topographical resurvey of the ocean shore of New Jersey from a point about two miles south of Townsend's Inlet towards Corson's Inlet between Ludlam's Beach and Peck's Beach.

Actual plane-table work began June 5, 1885, and was carried on uninterruptedly till October

28, when it terminated at a point one mile north of Corson's Inlet. The limit of the survey interiorly was the main road near the coast. Mr. Bache remarks that the margin mapped during the season is perhaps narrower than at any other place on the coast that has the topographical features of sand beaches and of interior marshes and waters, the average width of area surveyed being but three miles, while at some places along the coast it is seven miles.

Before leaving the field Mr. Bache proceeded, under instructions, to Sea Isle City and determined trigonometrically the position of the new Light-house at that place.

The statistics of the season are:

Miles of ocean shore-line surveyed	12
Miles of shore-line of thoroughfares, sounds, creeks, ditches, and low water	225
Miles of roads and streets	60
Miles of fast land-line	37
Area surveyed in square miles	30

During the winter Mr. Bache was engaged in office-work, and towards the close of the fiscal year was directed to resume his topographical survey from the limits of work of the previous season. He is now engaged in this duty, and expects to complete the resurvey, if the usual appropriation becomes available. Up to June 30, 1886, he reports the following statistics:

Miles of ocean shore line-surveyed	3
Miles of creeks and line of fast land	29
Miles of roads	7
Area surveyed in square miles	5

Completion of the topographic resurvey of the New Jersey shore of Delaware Bay.—The party of Assistant R. M. Bache was organized under instructions in May, 1885, for the continuation and completion of the topographic resurvey of the New Jersey shore of Delaware Bay. Owing to the limited balance of appropriation available to the close of the fiscal year 1884–1885, it became necessary to employ at first but two men in placing signals, repairing boat, &c., and then to work a short-handed party in the field from June 9 to June 30.

Beginning at Fortescue Creek, the survey of the shore-line and a belt of topographical detail inland, averaging two miles in width was carried to Jacob's Creek, nearly opposite Bombay Hook, on the Delaware shore of the Bay. Scale of survey 1–20000.

Mr. Bache remarks that the season was remarkably good for field-work, almost the only time lost in its direct execution being two days, when, through malicious mischief, some persons unknown removed the signals for several miles along the bay shore.

Some four or five days also were occupied in supplying a deficiency in the triangulation, at one end of which a signal had been destroyed and its subsoil mark removed by some evil-disposed person, and at the other end an important signal and its underground mark destroyed by a storm. But despite these disadvantages and the annoyance from the clouds of mosquitoes, remarkable even in that locality, the almost uniform excellence of the weather was such that the season was a productive one, and the work was prosecuted to completion within an area difficult to reach either by wagon or by boat, the general character of the ground being marsh, intersected by a meshwork of rivers and creeks, and with long tongues of fast land protruding into it from the upland towards the shore of Delaware Bay.

The work was closed October 8. Mr. Bache reports the following statistics:

Miles of shore-line surveyed	43
Miles of roads	40
Shore-line of creeks and ponds in miles	200
Area surveyed in square miles	28

During the winter Mr. Bache was engaged in office-work, and towards the close of the fiscal year received instructions to take up the topographical resurvey of the shores of Raritan and Sandy Hook Bays.

Physical hydrography—Changes in the Joe Flogger Shoal, Delaware Bay.—Assistant Henry Mitchell devotes a portion of his annual report to a study of the changes in the Joe Flogger Shoal, which, as he observes, forms the central prong in the submerged delta of the Delaware. His study

is based upon two excellent surveys made forty years apart, the first by Lieut. George S. Blake, U. S. N., Assistant Coast Survey, in 1841–1843, and the second by Assistant H. L. Marindin and by Lieuts. H. B. Mansfield and Francis Winslow, U. S. N., Assistants, in 1882–1883. He discusses the location, crest, width, mean depth, and sectional area of the shoal as derived from the surveys, and accompanies his report (Appendix No. 10) by comparative tables of dimensions and of channel depths in 1841–'42 and 1883. He shows that this remarkable shoal has lost over a mile of its length, and that in this mile the bottom has dropped thirteen feet. Other shoals have been less affected, but a vast change is in progress, which extends to the mouth of the bay.

Mr. Mitchell acknowledges his indebtedness to Assistant C. H. Boyd, Mr. W. B. Fairfield, and Mr. C. J. Meade for aid in making the necessary projections, diagrams, and tables.

Completion of the hydrographic resurvey of Lower Delaware Bay and Entrance.—Under instructions bearing date of June 17, 1885, Lieut. F. H. Crosby, U. S. N., Assistant Coast and Geodetic Survey organized his party on board the steamer Gedney and proceeded to Delaware Entrance, where he took up the hydrographic survey from the limits of the work of the preceding season. A portion of it was in the vicinity of Cape May, New Jersey, and covered the channels leading to that cape and the shoals adjacent to them. The remainder was in Maurice River Cove, bounded by a line from near Town Bank, New Jersey, to Cross Ledge Light, and thence to Egg Island Light. Also, in Maurice River, the hydrography of which was completed to Wiggins' Landing.

Besides the above, an obstruction in Delaware River near Wilmington, Del., and a lump behind Delaware Breakwater were examined and located.

Tides were observed at Cape May Point during the work in that vicinity, and the plane of reference used was that established by Lieutenant Hanus in 1884. Other tide stations were at Egg Island Light, New Jersey, Maurice River Light, New Jersey, at Port Norris, N. J., and at a point off Fishing Creek, about one-third of the distance from Maurice River to Cape May Point, This last named was for purposes of comparison only.

Two attempts were made to get a comparison between Maurice River and Cape May Point, with the intention of using the same plane of reference throughout the season's work, but there was such an evident dissimilarity of tides that Lieutenant Crosby felt obliged to place no reliance upon the comparison, and to establish a plane of reference at Maurice River by continuous observations for one lunation. Between the three gauges at Maurice River, Egg Island, and off Fishing Creek the agreement was very close.

Lieutenant Crosby remarks that a comparison of all of the tide stations as to times of high and low water, together with a perceptible increase of rise and fall observed in the bottom of Maurice River Cove, seems to indicate that the tide flows directly into the bay, following the channels, and turns back into the cove from the vicinity of Brandywine Shoal. This would also account for the fact that along the east side of Egg Island Point the flood tidal current sets very strong to the southward.

The whole of Maurice River Cove to the northward of Deadman's Shoal and to the eastward of Egg Island is staked out into private oyster claims. The stakes are set pretty thickly over this whole area during the summer and fall, but are all carried away by the ice in the winter. In this business not far from two hundred schooners and sloops are engaged, and an average of twenty car-loads of oysters are forwarded daily by railroad from Port Norris, N. J., during the season beginning September 1. Large quantities are also shipped to Baltimore by water

Lieutenant Crosby closed his hydrographic work October 31, unfavorable weather making it impracticable to undertake some off-shore work in the vicinity of Cape Henlopen.

The following-named naval officers were attached to the party on board the Gedney: Ensigns T. M. Brumby, A. L. Hall, J. H. Hetherington, F. W. Kellogg, J. S. Watters, and G. W. Street, U. S. N. Ensign Kellogg was detached July 31, 1885; Ensign Street joined the ship August 31.

The statistics are:

Miles run in sounding	1,450
Angles measured	11,397
Number of soundings	91,169
Area covered in square miles	121
Number of specimens of bottom preserved	38

In November the steamer was taken to New York, and was there fitted for service on the coast of Louisiana. Reference to Lieutenant Crosby's work on that coast will be made under the heading of Section VIII.

SECTION III.

MARYLAND, DISTRICT OF COLUMBIA, VIRGINIA, AND WEST VIRGINIA, INCLUDING BAYS, SEA-PORTS, AND RIVERS. (SKETCHES NOS. 1, 4, 14, 16, and 17.)

Special survey for the Harbor Board of the City of Baltimore.—Request having been made by Mr. N. H. Hutton, Engineer of the Harbor Board of the City of Baltimore, in behalf of that Board for the detail of an officer of the Coast and Goedetic Survey to mark out the Port Warden lines of the city, and connect them with the triangulation of the Survey, Assistant O. H. Tittmann was instructed early in June, 1886, to confer with Mr. Hutton and execute the work desired.

Mr. Tittmann began the necessary examinations June 15, and at the close of that month was engaged in making trigonometric observations, assisted by Mr. J. Henry Turner, Aid in the Survey.

Magnetic observations at Baltimore and Washington.—Determinations of the magnetic declination, dip, and intensity were made by Subassistant J. B. Baylor in the fall of 1885 at Fort McHenry, Baltimore Harbor, in order to obtain results which would afford additional material for ascertaining the secular change of the magnetic elements. The station of 1885 was the same as that occupied by Mr. Baylor in 1877, and near the station at which similar observations were made by Assistant Schott in 1856.

Before and after his season's work (which is referred to under the heading of Section II) Mr. Baylor observed at the station on Capitol Hill, Washington, with the dip circle, to determine the intensity by the Lloyd method at the several places of observation during his magnetic tour.

Annual determination of the magnetic dip, declination, and intensity at the station on Capitol Hill, Washington, D. C.—Determinations of the magnetic declination, dip, and intensity have been made annually at a station on Capitol Hill, Washington, by Assistant Charles A. Schott during a period of nineteen years and at less regular intervals for thirty years. The results of the observations made June 14, 15, and 16, 1886, proved to be in accord with the amount of annual change heretofore determined for the magnetic elements. Assistant Schott remarks that the old magnet used for the measure of the earth's magnetic intensity was found not to have lost magnetism appreciably for ten years, a fact which he supposes due to the position in which the magnet is kept, north end down, so that it is always under the influence of the earth's induction.

These determinations, made with care and skill, and under practically unchanging conditions during so many years, have an exceptional value as a contribution to our knowledge of the secular change of the magnetic elements on the Atlantic seaboard.

Determination of the geographical position of the Washington Monument.—In order to determine trigonometrically the geographical position of the Washington Monument, Assistant C. H. Sinclair was directed to connect it with the triangulation of the District of Columbia. He began this work April 7, 1886, erected the necessary signals and made all the observations required in four days. Stations Reform School, Du Pont, Stanton, and Insane Asylum were occupied, with enough observations from the latter point to bring the station Theological Seminary of the main series into the scheme.

On account of the known angles and distances in the adjusted triangulation of the District of Columbia it was only necessary to measure a few angles at the four stations above mentioned to bring in the Washington Monument. Nine angles were measured by two hundred and fifty-four observations with a ten-inch Gambey theodolite.

The records and computations were deposited in the office. Other duty assigned to Mr. Sinclair is referred to under the headings of Sections II, XV, and XVI.

Continuation of the detailed topographical survey of the District of Columbia.—At the beginning of the fiscal year the topographical survey of the District of Columbia, under the direction of Assistant J. W. Donn, had been advanced westward to an irregular line drawn from a point on the Potomac River, southwest of the junction of the Conduit and New Cut roads, northeasterly, to Battery Parrott on the Ridge road, thence to the angle of Tunlaw road at the crossing of Foundry

Branch, and along that road to the Tennallytown and Rockville turnpike, and northeastwardly from that point to Woodley lane, along that road to the Klingle Ford road, down that road to Klingle's line, and thence in an irregular line to Rock Creek Ford road and the Daniel road, and from thence to the crossing of the District line by the Seventh street road.

During the summer and fall months of 1885 the operations of Mr. Donn's party were principally confined to the open country adjacent to the Tennallytown and Pierce's Mill roads, Woodley lane and the Grant Military road, and the Loughborough and Tunlaw roads. There were many small areas of woods that could not be entered until the trees became bare of leaves, but these were completed early in the winter. Klingle Ford road was opened in September, and to make the original sheets upon which it fell perfect, its line was run and its grades connected with contours formerly run, as soon as it was possible to work to advantage through that heavily-wooded region.

During the period of the most intense cold, while the snow covered the ground, work was entered upon in the valley of Soapstone Creek, an area very difficult to pass through with an instrumental survey, being thickly covered with woods and entirely shut in from facilities for the determination of positions by means of triangulation points. The only resource was the running of numerous traverse lines intersecting and checking each other. Excepting the area lying within the angle of the Grant Military and the Broad Branch roads the work was satisfactorily completed by the time the opening leaves again compelled a return to open grounds.

In May, 1886, the survey was resumed on the western side of Foundry Branch and pushed across the Ridge road and over the country bounded by that road and the Conduit and Chain Bridge roads.

Mr. Donn's report is accompanied by a map showing the area over which the survey had been completed at the beginning of the fiscal year and the additional area surveyed up to June 30, 1886. After a full consideration of the amount of work accomplished, he comes to the conclusion that the work will be completed in the time originally estimated, namely, ten years from the beginning in February, 1881.

The office-work, which involves the preparation of original sheets for the archives of the Survey and the preparation of tracings, drawings, and level records for the immediate use of the Engineer Commissioner of the District, keeps Mr. Donn and his party closely occupied upon all occasions when active field-work is impossible.

Gravity research.—Pendulum oscillations at Washington.—Reference has already been made under the heading of Section II to the occupation of a series of gravity stations by Assistant Charles S. Peirce with the invariable reversible pendulums, Peirce No. 2 (a meter in length) and No. 3 (a yard in length).

For comparison with the results at these stations, the same pendulums were oscillated in April, 1886, at the permanent gravity station which had been established in the Smithsonian Institution. For this work time signals were furnished by the Superintendent of the Naval Observatory.

Approximate results have been obtained and the final reductions are in progress.

Hydrographic examinations for the Coast Pilot in Chesapeake Bay and its tributaries.—In pursuance of instructions dated April 6, 1886, Lieut. G. H. Peters, U. S N., Assistant Coast and Geodetic Survey, took command of the steamer Arago, and, having organized his party on board of her, took up such hydrographic examinations in Chesapeake Bay and its tributaries as were needed to complete for publication the manuscripts of Subdivisions 17 and 18 of the Atlantic Local Coast Pilot.

These examinations included the Potomac River and the streams tributary to it, Tangier and Pocomoke Sounds and their tributaries and the more southerly waters on the eastern shore of the bay, the waters of the lower bay and the rivers of its western shore, including the Patuxent and the Patapsco, and extended thence to the northward for work in the upper bay and its tributaries.

Lieutenant Peters reports that much delay and serious inconvenience was caused by frequent rains and fogs.

With regard to the charts of the Survey which he had occasion to consult and study in connection with the Coast Pilot work, he observes that while the field-work for some of them was done many years ago, yet in these cases the changes that have taken place do not materially affect their value for such waters as a stranger would be apt to attempt to navigate by a chart.

On June 16, having completed the work assigned to him, Lieutenant Peters was detached from the Arago and ordered to Washington to resume his duties in the office.

Search for a shoal reported off Assateague Light.—A shoal having been reported off Assateague Light, and not laid down on the charts, in a letter from the Hydrographer of the Navy Department, under date of October 1, Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Blake, was directed to make search in the vicinity. Lieutenant Pillsbury reports that neither the soundings he took, nor any of the evidence he obtained from the captains of coast-line steamers who pass over or very near the locality every trip, gave indications of shoal water as reported. He thinks it probable, therefore, that the schooner which struck was out of her reckoning.

Examination of line of precise levels from Hagerstown, Md., to Fortress Monroe, Va.—An error of apparently a meter having been discovered in the line of precise levels from Hagerstown, Md., to Fortress Monroe, Va., Assistant J. B. Weir, was instructed to organize a party for the purpose of making a close examination of the line in order to ascertain where the error in it had occurred.

The party was organized at Richmond, Va., and the work begun May 28. In making the examination, the method adopted was to connect the line of levels with tide-water at Washington, Fredericksburg, and Richmond, thus dividing the whole line into four sections from fifty to ninety miles each. As the line had been referred to tide-water at Washington in 1884, the work of examination was begun at Richmond. Reference to the tide-gauge used by the Army Engineers in the improvement of James River gave mean half-tide as observed at Richmond 0.1258 meter above mean sea-level at Fortress Monroe. The connection that was made with tide-water at Washington gave mean half-tide as there observed 0.30 meter above mean sea-level at Sandy Hook. Mean half-tide at Washington and Richmond should be approximately the same above Sandy Hook and Fortress Monroe, but the line of levels gives a difference of 0.174 meter, or 6.85 inches. This led to the supposition that the error was probably a cumulative one; hence it was decided to run a single line of check levels as far as Ashland, Va., sixteen miles from Richmond, and the tendency to cumulative error being sufficiently marked in this distance, it was thought best to continue the line of check levels to Milford, forty miles from Richmond. From Richmond to Milford there was a cumulative error of 0.198 meter, or about 7.8 inches.

The old line was then connected with tide-water at Fredericksburg. This gave mean half-tide as observed at Fredericksburg 0.4968 meter above Sandy Hook, indicating a cumulative error of 0.1968 meters between Washington and Fredericksburg.

Results obtained by continuing the line of check levels from Milford to Fredericksburg left little reason to doubt this tendency to cumulative error in the line of geodesic leveling between Hagerstown and Fortress Monroe, and show the necessity of adopting such checks as will reduce it to a minimum.

Field operations were closed and the party disbanded June 23, Mr. Weir reporting for duty at the Office. He ackowledges the efficient service rendered by Mr. John Nelson, Aid.

Completion of the survey of the boundary line between the States of West Virginia and Pennsylvania.—Full reference has been made under the heading of Section II to the work of ranging out and marking the boundary line between the States of West Virginia and Pennsylvania, which follows closely the parallel of 39° 43′.3. Undertaken in 1883, at the request of the Joint Commissioners of the two States, and placed in charge of Assistant C. H. Sinclair, with the aid of Assistant C. H. Van Orden, and partly finished in that year, the work was resumed, with the approval of the Department, by Mr. Sinclair, under instructions, in September, 1885, and completed.

Copies of Mr. Sinclair's report and of the maps accompanying have been furnished to the Joint Commissioners; a copy has been deposited also in the archives of this Office.

SECTION IV.

NORTH CAROLINA, INCLUDING COAST, SOUNDS, SEA-PORTS, AND RIVERS. (SKETCHES NOS. 1, 5, 16, and 17.)

Special hydrography.—Surveys of oyster-beds for the State of North Carolina.—Application having been made by the State of North Carolina for the aid of the Coast and Geodetic Survey in making a survey of the oyster-beds of that State, Lieut. Francis Winslow, U. S. N., Assistant

Coast and Geodetic Survey, commanding the schooner Scoresby, was instructed to undertake this work in March, 1886. The previous experience of this officer in investigations and surveys of a similar character in Chesapeake Bay and its tributaries had specially qualified him for the proposed surveys in the sounds of North Carolina.

Leaving Norfolk April 2 and passing through the Albemarle and Chesapeake Canal, the Scoresby reached Beaufort, N. C., April 11. The passage through the North Carolina sounds was utilized by a rough examination of the ground to be gone over, by observations of water densities, and the collection of information expected to be of use in the future. On the 12th of April active work in the field was begun, its general scheme contemplating the establishment with reference to Coast Survey triangulation points of all the oyster-beds of the State; that is, to define them as accurately as possible on regular projections, and then to examine more generally the areas supposed to be suitable for the planting of oyster-beds and as far as possible to indicate on the charts the extent of such areas and their location.

The determination of the positions and areas of existing oyster-beds is accomplished by the methods usually employed in hydrographic surveys, modified or expanded as circumstances may require. They are detailed at length in Lieutenant Winslow's elaborate paper on the Chesapeake beds, published as Appendix No. 11 to the report of the Superintendent for 1881. In the examination of areas presumed to be suitable for the maintenance of oysters is included the study of the depth and density of the water, character of the bottom, strength of currents, action of wind and tide, and effect of ice, freshets, and other abnormal influences. A study of the fauna is also required.

All of these various branches of work were kept in active prosecution from the time of beginning the surveys, and by June 30 had included the Newport and North Rivers, the inlet of Back Sound, and the greater portion of Core Sound.

Up to the close of the fiscal year Lieutenant Winslow reports that about fifty thousand acres of ground had been gone over and about two thousand beds had been located, and that although it was not then possible to fix their exact areas, the total area was inconsiderable when compared with the large acreage which is suitable for oyster culture.

It is expected that the data collected by the party and the information which will be available by the close of the season will enable the legislature of the State to adopt some scheme by which the enormous area now unproductive may be turned to account.

Connection of the triangulations of 1853 *and* 1873 *on the coast of North Carolina.—Beach measurement near the boundary line between North and South Carolina.*—In order to make a connection between the triangulations of 1853 and 1873 in the vicinity of Beaufort, N. C., and to execute other work required on that coast, Subassistant W. C. Hodgkins was instructed to organize a party in December, 1885. Upon reaching Beaufort in January. 1886, he began without delay the work of searching for the old triangulation points in Core Sound, Beaufort Harbor, and Bogue Sound. The extremely cold weather and the hard frozen ground was unfavorable for field operations; the sounds and creeks were for the most part closed by ice.

Until the middle of February the search for the old points was continued without much success, but three being found out of fourteen. Much time was necessarily consumed in digging for the underground marks.

At this stage of operations, and before taking up the triangulation, the work was temporarily suspended in order to transfer the party to Smithville for the purpose of co-operating with the party of Assistant D. B. Wainwright in the beach measurement intended to connect the triangulation of Cape Fear River with that near Little River, where the boundary line between North and South Carolina touches the coast.

For the double purpose of economy in transportation and to reconnoitre the coast between Beaufort and Cape Fear, Mr. Hodgkins obtained a sharpie drawing about ten inches of water and in it left Beaufort, February 18, with his tents, instruments, and two men, making the trip mostly through the narrow creeks and shallow sounds lying between the beach and the mainland. He found but little difficulty in proceeding except on the divides between the inlets at low tide.

Arriving at Fort Caswell, Cape Fear River Entrance, February 23, and joining Mr. Wainwright's party there, a wire measurement along the beach was begun by the two parties conjointly,

the angular measurements needed being made in part by Mr. Wainwright and in part by Mr. Hodgkins.

Upon the completion of this work early in May, and the reference of the beach measurement to the meridian by the measurement of an astronomical azimuth at Fort Caswell, Mr. Hodgkins returned to his first field of labor, and took up the triangulation between Beaufort and Core Sound. In the measurement of the angles at the several stations it was generally found necessary to elevate the instrument about fifteen feet above the ground. The stations recovered, four in number, were connected by the triangulation with one of the sides of the old work, Davis Shore and Bell's Point, and farther towards Beaufort another connection was made at the Station Lynch. Unfortunately no point directly connected with Lynch in the old triangulation could be recovered, but the court-house at Beaufort was redetermined and affords an indirect check. The old point at Davis Island, connected with Davis Shore and Bell's Point, was also redetermined. Cape Lookout Light-house was connected with the triangulation of Core Sound, and a topographical survey was made of the shore of the important harbor of refuge in Lookout Bight.

Mr. Hodgkins observes that a small light on the point at the entrance of this harbor is much needed for the small vessels that frequent it.

The statistics of field-work, which closed early in July, 1866, are:

Number of signals erected	18
Number of stations occupied	20
Number of objects observed	105
Number of angles measured	113

Under the heading of Section II reference is made to duty assigned to Mr. Hodgkins earlier in the fiscal year.

Junction of the triangulation at the mouth of Cape Fear River with that at Little River Inlet.—In order to connect the triangulation of Cape Fear River, executed by Assistant C. P. Bolles, in 1853–'59, with that of Assistant O. H. Tittmann, carried up from the southward along the South Carolina coast as far as Little River Inlet, in 1873, Assistant D. B. Wainwright was instructed to organize a party early in December, 1885.

The work was begun by a search for the old points which had been established on the coast-line, the party being either in camp on the beach or making trips of several days' length in an open sail-boat. Much hardship was endured, owing to the unusual severity of the winter. No stations could be found south of Smithville, the changes that have occurred along the coast from the action of wind and tide being very great. It became necessary, therefore, to start the triangulation from three points in the vicinity of Smithville. The greater part of the distance was measured by wire; and from an azimuth observed at Fort Caswell, and carried southward by stations about four miles apart, the measurement was checked in direction.

In this work, which was finished May 4, Assistant W. C. Hodgkins co-operated most effectively, his own party and that of Mr. Wainwright working in conjunction.

Soon after Mr. Wainwright's return to Washington he received instructions to prepare for the resumption of topographical work near New York, as mentioned under the heading of Section II.

Hydrographic examinations in the vicinity of Frying Pan Shoals.—On the voyage northward of the steamer Blake, in command of Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey, examinations were made in June, 1886, in the vicinity of Frying Pan Shoals, North Carolina, to fix the locality of certain shoal spots recently reported as not shown on the charts. Search to the eastward of the light-vessel led to the discovery of a rocky patch of perhaps one-fourth of a mile in diameter, situated near the five and three-quarter fathom spot shown on the chart. The shoalest water on this patch of rock was found, by steaming and drifting over it with six leads going, to be four and three-quarter fathoms.

An examination made to the westward of the light-vessel to ascertain the correctness of the soundings shown on the chart developed the fact that Captain March, of the steamer Johns Hopkins, was probably correct in his statement that he had found thirteen and one-half fathoms near the position of eleven and one-half fathoms on the general coast chart, Cape Hatteras to Cape Romain. Lieutenant Pillsbury reports that he found twelve and three-quarter fathoms west of the

Light-vessel. He has forwarded to the office a sketch showing the soundings, with the position of the Light-vessel, and such corrections as are found necessary will be made on the chart.

The important work of the Blake in the Gulf Stream is referred to under the heading of Section VI; other hydrographic duty executed by Lieutenant Pillsbury is reported under the headings of Sections I, II, and III.

SECTION V.

SOUTH CAROLINA AND GEORGIA, INCLUDING COAST, SEA-WATER CHANNELS, SOUNDS, HARBORS, AND RIVERS. (SKETCHES NOS. 1, 5, 16, and 17.)

Magnetic observations at Aiken and at Charleston, S. C., and at Savannah, Ga.—The collection of material for perfecting the magnetic map of the United States was continued by Subassistant J. B. Baylor, under instructions dated in December, 1885. At Aiken, S. C., he established a magnetic station in the grounds of the new Court-House, on Railroad avenue, where he determined the declination, dip, and horizontal and total intensity by observations made December 21 to 23. A meridian line was fixed by observations on the sun for azimuth, and permanently marked by two granite posts sunk to a depth of two feet in the ground, their tops level with the surface. One of these posts is in the open space southeast of the Court-House; the other in the center of Railroad avenue.

Near Charleston, S. C., the stations occupied in 1849 and 1880, at Breach Inlet, on Sullivan's Island, were reoccupied, and the magnetic elements determined by two days' observations, December 29 and 30.

Mr. Baylor then proceeded to Savannah, Ga., and reoccupied the station of 1852, on Hutchinson's Island, opposite that city, determining the declination, dip, and intensity by two days' observations in January, 1886. These redeterminations will afford the means of ascertaining the secular changes in the magnetic elements at the localities indicated.

Under the heading of Section VIII reference is made to the occupation of two magnetic stations in Louisiana by Mr. Baylor while attached to the party of Assistant F. W. Perkins.

Hydrographic examinations in North and South Santee Rivers, Bull's Bay, Price's, Capers, and Dewees Inlets, and Charleston Harbor, South Carolina.—In conformity with instructions issued in December, 1885, Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey, having organized his party on board the steamer Endeavor, left New York for Charleston towards the end of that month, and early in January, 1886, began hydrographic work in Bull's Bay.

To obtain a plane of reference for the soundings, a staff-gauge was put up at Jack's Creek. Comparisons of this gauge, made from time to time during the progress of the work with the self-registering gauge at Fort Sumter, showed that the tides at the two places had the same rise and fall and that the high and low waters occured simultaneously. All of the soundings taken in Bull's Bay were reduced to the mean low water of the gauge at Jack's Creek. The bench-mark for this gauge is a brass bolt driven into the wall of an old fort in the point of woods about one hundred and fifty meters to the southward of the mouth of Jack's Creek.

During the months of February, March, and part of April the in-shore and off shore hydrography of Bull's Bay, Prices, Capers, and Dewees Inlets, and North and South Santee Rivers was completed as laid out on the projections. Staff-gauges were established at Capers Inlet and at South Santee River, and compared with the Fort Sumter gauge. For the work at the inlets, but one point of the old triangulation could be found; it became necessary therefore to measure a base on the coast and connect one of the ends of the base with the triangulation by observations for azimuth. The sounding was afterwards done either by camping parties from the inside or from the vessel anchored outside. Upon the completion of this work Lieutenant Hanus proceeded in the Endeavor to Charleston, S. C., and began a thorough examination of Charleston Bar, in order to determine the exact condition of the channels. Having obtained the positions of the Light-house tower, of all beacons and buoys, and a number of prominent land marks, he chained the entire beach of Morris Island in order to check his determinations, and also the beach of Folly Island to a point two miles below Light-House Inlet.

The most important result accomplished was the discovery and location of a dangerous wreck

in the main ship channel near the southern bar. Mariners were immediately warned of this danger by a Notice (No. 73) issued from the office of the Survey, May 12, 1886.

Another result of Lieutenant Hanus's survey was the preparation of full sailing directions for crossing the bar and entering the harbor, with recommendations for such changes in the aids to navigation as would make the entrance easy for the deepest vessels that enter the port.

The tidal observations used in the reduction of soundings on the bar were all obtained from the staff-gauge at Fort Sumter wharf. A great number of observations were obtained also from the self-registering gauge at Fort Sumter.

The Charleston Harbor work was finished the middle of May, and the Endeavor was taken north. On the way up the coast, Lieutenant Hanus made examinations for the location of a shoal reported off False Cape, Virginia. He states that a number of shoals were found, but that none of them ought to be dangerous, for the simple reason that no navigator ordinarily cautious could be caught so near the shore in the vicinity of a shoal already charted.

Following are the statistics of the season's work in South Carolina and Virginia:

Miles run in sounding	571
Angles measured	5,861
Number of soundings	45,536

Other duty executed by Lieutenant Hanus is referred to under the heading of Section II.

SECTION VI.

PENINSULA OF FLORIDA, FROM SAINT MARY'S RIVER ON THE EAST COAST, TO AND INCLUDING THE ANCLOTE KEYS ON THE WEST COAST, WITH THE COAST APPROACHES, REEFS, KEYS, SEA-PORTS, AND RIVERS. (SKETCHES Nos. 1, 6, 16, and 17.)

Physical hydrography—Observations of currents in the Gulf Stream—Deep-sea soundings from Florida Reefs to Salt Key Bank and thence to Bahama Banks—Examination of seventeen-feet spot in Southwest Channel, Key West Harbor.—The investigation of the currents of the Gulf Stream, which had been begun with special methods and appliances in the winter of 1884–'85 by Lieut. J. E. Pillsbury, U. S. N., commanding the steamer Blake, was resumed by that officer in March, 1886. All preparations for the work had been completed early in January, but the Blake was detained at the Washington Navy-Yard by ice in the Potomac till February 16.

On reaching the Florida coast, a tide-gauge was established near the fort at Garden Key, Dry Tortugas, in order to gain some knowledge of the relation, if any, existing between the entrance of the tidal wave into the Gulf of Mexico and the variation in the velocity of the Gulf Stream on cross-section A of the season of 1885 between the Fowey Rocks and Gun Cay.

Every opportunity was taken during the season to obtain the observations for currents, the only break of any length of time being about ten days, when it became necessary to go to New Orleans for bituminous coal, that at Key West having been destroyed in the great fire there in the early part of April. When at anchor in the Stream, the Blake needed to have at all times a great pressure of steam on her boilers, so that the anchor could be weighed and the engines started at a moment's notice, and for this reason hard coal could not be used.

The weather in March and April was abnormally bad, strong northerly winds and heavy seas prevailing most of the time, and in its general character the season was totally unlike that of the year before. At the Bahamas and at Key West the winter of 1885–'86 was said to have been more severe than ever before known, fish in vast numbers having been killed or benumbed on the shoals. In 1885 during April and May there was seldom a day on which rain did not fall, while in 1886 there was scarcely one shower during either month. From local evidence Lieutenant Pillsbury concludes that 1885 was nearly a normal year while 1886 was abnormal.

Current meters of the same pattern as those of last year were used in taking the observations. These meters were described and figured by Lieutenant Pillsbury in his paper published as Appendix No. 14 to the report for 1885. This season, one meter was used for the surface and another for the subsurface currents, and the two were frequently interchanged. This increased the rapidity with which the data for any depth were obtained. Some changes to secure greater efficiency were also made in the anchoring gear.

In his elaborate report, which appears as Appendix No. 11 to this volume, Lieutenant Pillsbury submits a discussion of the most salient features presented by the observations of the season of 1886, including those also of the year before, in order to show the agreement between the two. He considers:

I.—The general characteristics of the Gulf Stream as developed by the observations.
II.—The daily variation of the Stream.
III.—Its monthly variation.
IV.—Axis of the Stream.
V.—Effect of wind on its velocity and the position of its axis.
VI.—Depth of the Stream and velocity at different depths.
VII.—General summary, with rules for the guidance of navigators.

Referring to his report of last year's observations in the same waters, he concludes from the observations of this year also that there is a daily variation of the Stream, that there is a monthly variation, and that the axis of the Stream is not situated at the point at which it was generally supposed to be. These were his conclusions of last year, and he finds no occasion to reverse or modify them.

With regard to the velocity of the current, he remarks, towards the close of his paper, that the examinations having been made in March, April, May, and June, the conclusions may be incorrect for other seasons of the year, although there are no good reasons for supposing such to be the case, except possibly in the amount of the variations. He finds that between Fowey Rocks, Florida, and Gun Cay, Bahamas, the current varies daily in velocity, at times as much as two and a half knots, the greatest velocity being generally about nine hours before the upper transit of the moon; that the variations are most excessive on the west side of the straits and least on the east side; that the average daily currents vary during the month, the strongest coming a day or two after the greatest declination of the moon; and that the axis of the Gulf Stream at this point (the position of the strongest surface flow) is eleven and one-half miles east of the Fowey Rocks Light-house. The strongest surface current found here was five and one-quarter knots per hour, the least one and three-quarters knots, and the average three and six-tenths knots.

Lieutenant Pillsbury's report is accompanied by complete records of his observations, and by diagrams representing graphically the daily and monthly variations in the strength of the current, the velocities at different depths, &c. He acknowledges the hearty and intelligent co-operation of the officers attached to the party (Ensigns T. D. Griffin, R. M. Hughes, A. G. Rogers, J. H. Hetherington, and F. R. Brainard, U. S. N.), and makes special mention of the master-at-arms, Jens Petersen, to whose care and vigilance and knowledge of the mechanical portion of the working gear much of the success of the season was due.

The statistics reported are:

Number of current stations occupied	26
Number of current observations with meter	1,557
Number of current observations with pole	1,807
Greatest depth in fathoms in anchoring at any one station	498

Before proceeding northward Lieutenant Pillsbury ran a line of deep-sea soundings from the Florida Reefs to Salt Key Bank, and thence to the Bahama Banks, and directed the examination of a seventeen-feet spot found in Southwest Channel, Key West Harbor.

Other hydrographic duty executed by him is reported under the headings of Sections I to IV, inclusive.

Beach measurement and triangulation, with observations for latitude and azimuth, on the west coast of Florida between Cape Sable and Cape Romano.—In order to fill the gap in the survey of the west coast of Florida between Cape Sable and Cape Romano, and specially with a view to obtain the shore outlines for the coast charts, Assistant Joseph Hergesheimer was instructed to organize a party in the schooner Quick. After repairing the vessel and completing his preparations for the season's work on that comparatively isolated coast, Mr. Hergesheimer made an anchorage at Sanibel Light-house, January 3, 1886. This Light-house, which stands on the east end of Sanibel Island, near the entrance to San Carlos Bay and the port of Punta Rasa, was determined

in geographical position, three stations being occupied for this purpose, and also an eccentric station at the Light-house.

The next work executed was the beach measurement from Cape Romano to Caximbas Pass, in order to determine the position of Cape Romano, and obtain a base from which to carry the triangulation towards Cape Sable. For this work the party was established in camp at Caximbas and at Cape Romano, the schooner having been left in charge of one man in a safe anchorage inside of Coon Key.

The line measure was made with beach-tapes over trestles which were aligned and leveled. This work, with the erection of signals at Caximbas Pass and Cape Romano, and those needed on the line, was finished February 3, and in order to determine the azimuth of the line, Subassistant E. D. Preston with Aid J. H. Gray were left in the camp already established at Cape Romano, while Mr. Hergesheimer availed himself of a trip of the schooner to Punta Rasa for water and provisions to make a reconnaissance of the coast from Cape Romano to Coral towards Pavilion Key, and erected signals at Coon Key, Johnson, Horse Key, and Coral, and a water signal at Flossy.

Upon the completion of the observations for azimuth at Cape Romano the party was transferred to the schooner, and proceeding to Cape Sable, an astronomical station was established there for the determination of the latitude, and the azimuth of the line, Cape Sable to Palm Point. While this work was in progress signals were erected for the triangulation between Cape Sable and Cape Romano. The necessary reconnaissance, erection of signals, and the observations of horizontal angles occupied the time between April 7 and May 2. At that date, the astronomical work having been completed, Mr, Preston proceeded north under instructions, and Mr. Hergesheimer took up the work of recovering the primary base-line at Cape Sable, which had been measured by Superintendent Bache in 1855. The difficulties incident to this work, arising from changes in shore-line and the growth of trees during thirty-one years, were successfully overcome. Heavy cutting was required to open the line from the astronomical station to West Base. The marks at this end of the Base were found in good condition. The direction to East Base was then carefully laid off, the distance measured with a chain, and the station mark at East Base together with the intermediate mile-posts found in good condition. The azimuth and latitude station at East Cape was then connected with the Base, and on the completion of this work June 2, field operations were closed for the season.

For the several classes of work executed, the statistics reported by Mr. Hergesheimer are as follows:

Connection of Sanibel Light-house with the triangulation of San Carlos Bay, Florida:

Stations occupied	3
Number of angles measured	3
Number of observations	96

Beach measurement, Caximbas Pass to Cape Romano, and triangulation, Caximbas Pass to Pavilion Key:

Distance measured, in meters	7,864.5
Number of stations occupied	25
Number of angles measured	68
Number of observations	970

Triangulation for connecting astronomical station with Base:

Number of stations occupied	3
Number of angles measured	8
Number of observations	192

Observations for azimuth and latitude:

Number of sets of observations for azimuth at Cape Romano	28
Number of sets of observations for azimuth at Cape Sable	36
Number of separate results for latitude at Cape Sable	100

With regard to the general character of the coast between Cape Sable and Cape Romano, Mr. Hergesheimer observes that, with the exception of Cape Romano Shoals, the soundings in

approaching the shore from the Gulf are regular, with nine feet of water for two or three miles off the Keys, and shoaling gradually from that depth and in that distance to the shore, with good holding ground, a hard clay in many places soft and sticky.

Cape Romano is a dangerous shoal with breakers a long distance from the Cape. There is a very strong current running around the Cape, and during northers there is a heavy, broken, dangerous sea. In passing the Cape, vessels of any draught should keep in no less than five fathoms.

Many other details of interest to navigators are given by Mr. Hergesheimer in his report.

In making a reconnaissance for the connection of the triangulation between Cape Sable and Cape Romano he found the coast a mass of islands, covered with a growth of high mangrove trees. A beach measure would be impracticable, owing to the broken shore-line, and a triangulation, with all of the signals on shore, would involve the erection of very high tripods, much cutting, and heavy expense. He recommends, therefore, that the triangulation be carried along the coast by a system of signals, part on shore and part in the water, at an average distance from shore of four miles. By this method the triangulation from Cape Romano to Pavilion Key was completed with satisfactory results. These water signals, which would be in an average depth of about ten feet of water, will also be of much advantage to the hydrographic parties along the coast.

In the earlier part of the fiscal year Mr. Hergesheimer had assigned to him duty which is referred to under the heading of Section II.

SECTION VII.

PENINSULA OF FLORIDA, WEST COAST, FROM ANCLOTE KEYS TO PERDIDO BAY, INCLUDING COAST APPROACHES, BAYS, AND RIVERS. (SKETCHES NOS. 1, 6, 16, and 17.)

Topographical survey of the west coast of Florida, north of Anclote Keys.—For the completion of the topographical survey of the west coast of Florida, north of Anclote Keys to the southern limit of the survey of 1869 at Wall Creek, Subassistant W. Irving Vinal was instructed to organize a party in November, 1885.

Mr. Vinal located his first camp at Point Richey, at the mouth of the Pithlochasscootie River, and began his survey early in January, 1886. By going back to the work of 1884 he was enabled to start a plane-table triangulation along the coast, and thus to recover many of the points established in the surveys made between 1857 and 1861. The location of the camp was changed to Hudson, Hamack Creek, and finally to Bayport during the season.

More than usual difficulties were encountered in making the survey on account of the extremely shoal water of the Gulf of Mexico near the coast line, the entire lack of beach, the frequency of small creeks, and the absence of roads. Facilities for transportation were extremely limited, involving delays and much expense. During part of January the weather was so severe that field-work had to be suspended, the party suffering great inconvenience and hardship on account of the frequent northers and the extreme cold.

The various features of the country, as shown on the plane-table sheets, are the shore-line, rivers and creeks, islands lying adjacent to the coast; oyster reefs and exposed rocks; extensive salt marshes containing islands, ponds, and out-cropping limestone rock; woods, including mangrove, palmetto, scrub, cedar, pine, oak, and mixed hummock.

Tracings of the shore-line, showing location of positions determined by the plane-table, were furnished to the hydrographic party on board the steamer Bache, Lieut. J. M. Hawley, U. S. N., Assistant Coast and Geodetic Survey, commanding.

Mr. W. B. Mapes, who was attached to the party as acting aid, was taken seriously ill in February and died on the 25th of that month.

The following statistics of the survey, which was included in two plane-table sheets, scale 1-20000, are reported:

Miles of shore-line surveyed	116
Miles of creeks and ponds	75
Miles of roads	13
Miles of marsh boundary	44
Area surveyed in square miles	38

Work executed by Mr. Vinal earlier in the fiscal year is reported under the heading of Section II.

Hydrographic survey off the west coast of Florida to the north of the Anclote Keys.—The party of Lieut. J. M. Hawley, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Bache, having completed certain hydrographic work in the vicinity of the Chandeleur Islands and in Horn Island Pass, as stated under the heading of Section VIII, arrived at the working-ground north of Anclote Keys March 2, and in pursuance of instructions began a hydrographic survey in the vicinity of Bayport.

The shore-line and geographical positions, as far as determined, were obtained from Subassistant W. I. Vinal, who had charge of a topographical party on that coast. A tide-gauge was established at Bayport, and observations kept up throughout the season, night and day, by two observers detailed for the purpose. Soundings were begun March 11, and from that date were continued whenever the weather would permit till May 24.

During March and the greater part of April the weather was very unfavorable for sounding, but May proved to be a most favorable month for the work, and full advantage was taken of it; two parties working daily, leaving the ship at 6.30 a. m. and returning not earlier than 5 p. m., and sometimes much later. During a short time in April it became necessary for the steamer to be away, having to go to Mobile for coal, and in order that the work might go on without interruption, Lieutenant Hawley established a party of four officers and twelve men on shore at Bayport in charge of Ensign E. E. Wright, giving them the steam launch and one boat to be used in sounding and other work. Unfortunately the launch broke her shaft the first day out, so that the party had to depend entirely on the boat; still they ran over one hundred miles of soundings and erected a number of signals during the ten days the ship was away.

Lines of sounding were run with the ship at a distance of one mile apart, connecting with the boat work and extending out to a depth of ten fathoms; most of these lines were over twenty miles long, and their outer limit was from thirty to thirty-five miles from the shore-line.

Observations to find the strength and direction of the tidal current were taken at different anchorages of the ship, but no very satisfactory results were obtained, since the direction and strength of the current appears to be almost wholly influenced by the direction and force of the wind.

The results of this survey are shown upon two hydrographic sheets, each upon a scale of 1–40000. The statistics are:

Miles run in sounding	1,701
Angles measured	3,734
Number of soundings	39,489

In closing his report, Lieutenant Hawley commends the hearty co-operation of the officers of the Bache in his plans for carrying on the survey.

Ensigns E. E. Wright, A. W. Dodd, John E. Craven, R. O. Bitler, and Harry A. Field, U. S. N., aided in the work.

The following navigation notes communicated by Lieutenant Hawley will be of interest:

"It is dangerous for vessels drawing nine feet or more of water to venture on Saint Martin's Reef, which extends from North Anclote Keys to Cedar Keys south, owing to the numerous coral reefs and oyster-beds that crop out in unlooked for places. By keeping in not less than fourteen feet of water these dangers will be avoided. There is a channel inside the reef extending from North Anclote Keys to the northward, in which nine feet can be carried as far as the survey extended this year. This channel is used by the coasting steamers. Formerly it was marked by a line of beacons placed about five miles apart, but there are none standing now. The anchorage at Bayport is available for vessels of four or five feet draught, and then only at high-water."

At the close of the season the Bache proceeded to Key West, and thence to New York, arriving at the latter port June 1. Early in that month Lieutenant Hawley received instructions to prepare for hydrographic work on the coast of Maine.

SECTION VIII.

ALABAMA, MISSISSIPPI, LOUISIANA, AND ARKANSAS, INCLUDING GULF COASTS, PORTS, AND RIVERS.

(SKETCHES Nos. 1, 5, 7, 16, and 17.)

Progress made in the extension of the primary triangulation in Northern Alabama towards the Gulf of Mexico.—Early in November, 1885, Assistant O. H. Tittmann, having organized his party under instructions, took up the extension of the primary triangulation in Alabama to the southward from the line Aurora–Indian.

Stations Indian, Cheehahau, Cahaba, and Aurora were occupied in succession for observations of horizontal directions, and as opportunity offered, for vertical angles. Cheehahau, fifty miles southwest of Indian and fifty-seven miles southeast of Aurora, is the highest point in Alabama. Few secondary points were observed upon owing to the impossibility of seeing them from more than one station, but, whenever practicable, elevated peaks were determined in position.

The winter was one of unusual severity and interfered seriously with the progress of the work. Delays were encountered also by reason of dense smoke or haze.

Field operations were brought to a close May 17, 1886.

Mr. Tittmann commends the efficient service rendered by Messrs. J. E. McGrath and J. Henry Turner, attached as aids to his party.

Other duty assigned to him during the fiscal year is referred to under the headings of Sections II and III.

Lines of geodesic levels run from Mobile to New Orleans, and from Meridian, Miss., to Quitman, Miss.—In order to ascertain the practicability of running a line of precise leveling from Mobile to New Orleans along the route of the railroad connecting those two cities, Assistant J. B. Weir was instructed towards the end of November, 1885, to make an examination of the road.

From Mobile, Ala., to Toulme, Hancock County, Mississippi, a distance of ninety-six miles, Mr. Weir found that the railroad passed through a low and flat country, wooded with pine, and that the road-bed was composed of sand, and furnished a good basis for the instrument and foot-plates. From Toulme to a point near New Orleans the road runs through a marsh of very unstable character naturally, but below which, at a depth of from three to fifteen feet, there was a solid sand bottom. By hauling sand and depositing it upon the road-bed, it had been made quite stable, so that it furnished quite a good route for the line of levels.

Between Mobile and New Orleans there are the following-named bridges and trestles:

	Meters.
East Pascagoula bridge	210
West Pascagoula bridge and trestle	735
Biloxi Bay trestle	1,842
Bay Saint Louis trestle	3,125
Pearl River bridge	274
The Rigolets	1,110
Chef Menteur bridge	280
Total length of bridges and trestles in meters	7,576

Having satisfied himself that with the exception of these bridges and trestles no serious obstacle would be offered to the work proposed, Mr. Weir organized his party and began work at Mobile December 4. In 1884 he had established a permanent bench-mark for reference of geodesic leveling operations on the custom-house in Mobile.

The first trestle encountered which retarded very much the progress of the work was that at Biloxi Bay. The track is ten feet above the surface of the water, and the trestle-work supporting it rests on piers fifteen feet apart and of six piles each. This was found to be very stable, so much so that at one point where a bench-mark was established on an old pile not connected with the trestle, but which stood near the track and could be observed carefully, no vertical motion was perceptible when an express train passed over the trestle at the rate of twenty-five miles per hour.

There was a draw-pier about half way of the trestle, and it was planned to cross the bay by

means of simultaneous observations on the west bank and on the draw-pier and then on the draw-pier and on the east bank, thus dividing the whole trestle into two sections, and reducing the length of the sights to one-half the width of the bay. Simultaneous observations were thus made on three different days. Encouraged by the great stability of the trestle it was decided to run a line of levels across the bay by setting up the instrument on the trestle and taking short sights each of about one hundred meters. A difference of but four millimeters between the greatest and least of four measurements was obtained, and this was a sufficient proof of the excellence of the results. Two of the lines across the trestle were run in an easterly and two in a westerly direction, and no trains passed while running from one bench to another. When winds and currents prevailed no good work could be done, but under the conditions under which the work was accomplished it is believed that this is as strong as any other part of the line.

At Bay Saint Louis both methods were used in crossing, but on account of the relatively long distance over the trestle-work it was thought best to run six lines instead of four.

At the Rigolets, on account of the depth of the water, forty feet in the channel, and the wind and almost continuous current, it was not possible to run a line over the bridge and trestle, so that the method of simultaneous observations alone was used, but the observations were continued until a good crossing was made.

On reaching the outer edge of the city of New Orleans, in order to avoid running through the most frequented streets, it was decided to take what is known as the Gentilly road, and so get around the city to Carrollton. At Carrollton, where the party arrived April 12, the line of levels was referred to the bench-mark established in 1875 on the iron step of the Carrollton Railroad depot.

Next day the party was transferred to Meridian, Miss., in order to accomplish as much as could be done with the balance of funds available, towards filling the gap in the line of precise leveling between that station and Citronelle, Ala., reference to which is made in the report for 1884. Upon reaching Quitman, Miss., about twenty-six miles in a southerly direction from Meridian, field-work was closed May 12, in accordance with instructions.

Mr. John Nelson, aid, served very acceptably throughout the season.

Under the heading of Section III reference is made to other work of geodesic leveling executed by Assistant Weir.

Hydrographic examination in the vicinity of the Chandeleur Islands and hydrographic resurvey of Horn Island Pass.—Instructions issued in November, 1885, directed Lieut. John M. Hawley, U. S. N., Assistant Coast and Geodetic Survey, to take command of the steamer Bache, and prepare her for service on the Gulf coast. In December, in pursuance of detailed instructions from the Hydrographic Inspector, Lieutenant Hawley completed his arrangements and organized his party on board the Bache, and after a stormy passage reached Key West January 19, having left New York January 7, 1886. He left Key West January 21, encountered strong northwesterly winds in the Gulf, and was obliged to put into Tampa Bay on two different occasions before he could continue on his course. Having taken in coal at Mobile, the steamer arrived at the northern end of the Chandeleur Islands February 5. Here Lieutenant Hawley put up a tide-gauge near Chandeleur light, and having provided for the services of a tide-keeper, he continued on with the ship down the outside coast of the islands, a distance of twenty-five miles, to the locality of the work assigned to his party. On February 6 three parties were sent out to erect signals, and on the 8th sounding was begun, using two boats for the in-shore work and the ship for off-shore soundings.

Four days sufficed to complete the soundings in this locality. Lieutenant Hawley found discrepancies between his own survey and the former one, not fully accounted for by the changes that had probably taken place during the forty years that had elapsed since the original survey, and he reports that in order to obtain a satisfactory explanation it will be necessary to begin a triangulation from a base established at the light-house, redetermine all signals, replot the hydrography executed in the spring of 1885, and then complete all new hydrography required. Lieutenant Hawley has transmitted to the office a tracing showing the location of the signals established by his party and the corrected shore-line.

On the 11th of February the Bache proceeded to Horn Island Pass. Finding that a mere examination, such as was contemplated by his instructions, would not develop as fully as was desirable

the facts wanted by local pilots and others interested in the commerce of East Pascagoula, Lieutenant Hawley made a complete resurvey of the Pass, from the anchorage inside of Horn Island to the sea buoy, developing a very crooked channel, through which can be carried at mean low water a least depth of nineteen feet. Over the bar proper can now be carried twenty and a half feet, where the old survey showed but seventeen feet.

A plane of reference for the soundings was established from the mean of the low waters, as determined by observations at a tide-gauge established on Horn Island. The signals used in the resurvey were located by occupying the several light-houses, Horn Island, Round Island, and East Pascagoula.

Lieutenant Hawley found that since the old survey, the point of Petit Bois Island has grown to the westward about a mile and a half. He observes that the people of East Pascagoula expressed much gratification at the fact of his making a complete survey of the channel, and seemed to feel that the future prosperity of their town depended upon the result.

Statistics of work at Chandeleur Islands and at Horn Island Pass are as follows:

Miles run in sounding	112
Angles measured	742
Number of soundings	4,775

Ensigns A. W. Dodd, John E. Craven, R. O. Bitler, and Harry Field, U. S. N., were attached to the party during the season.

On the 23d of February, after having coaled at Mobile, the Bache left for the west coast of Florida. An account of Lieutenant Hawley's hydrographic work to the north of Anclote Keys is given under the heading of Section VII.

Survey of the coast of Louisiana between Barataria Bay and the Mermentou River.—In order to cover that part of the coast of Louisiana lying between Barataria Bay and the Mermentou River by a survey sufficiently detached to admit of the completion of the coast chart of that locality, Assistant F. W. Perkins was placed in charge of that work in November, 1885, and authorized to adopt such methods as the peculiarities of the country, together with a due regard to a reasonable degree of accuracy, might suggest. Mr. E. L. Taney was at the same time placed in charge of a subparty as topographer under the general direction of Mr. Perkins.

The steamer Hitchcock was fitted out as a general headquarters and base of supplies and to accommodate the main party. No suitable vessel for the use of the secondary party could be found at short notice, but a small sloop was secured which was made to answer their purpose, though not without much inconvenience and discomfort.

The work of the triangulation was begun at the southwest pass of Vermilion Bay and carried westward to the limit of the work of 1884, within about eighteen miles of the mouth of the Mermentou River, after which the old astronomical station, Deer Island, at the mouth of the Atchafalaya River, was recovered, and the work was carried southeast from there to Isle Derniere and Ship Shoal Light.

The topography, commenced by a survey of the southern and eastern portion of Marsh Island, was carried around Vermilion Bay over the country triangulated westward from the southwest pass of that bay, and closed with a survey of the shores of Caillou Bay.

West of Vermilion Bay the coast is a low marsh, drained by four or five bayous. A thin layer of broken shells, a few meters wide along the Gulf shore, and the ridges of hard land known as Chemin Tigre and Mulberry Island near the coast, and Pecan Island in the back country, give a little variety to its general marshy character. Marsh Island, immediately to the eastward of Vermilion Bay, is a considerable body of very low marsh which separates Coté Blanche from Vermilion Bay, and has a narrow strip of hard land at its southern edge, beyond which sea-weed and a network of shell reefs extend for miles.

Caillou Bay, extending from Point au Fer to Isle Derniere, is a very shallow body of water, apparently without reefs or shoals, with shores formed by a succession of marsh islands, which separate it from a series of small bays, lakes, and bayous, navigable by small crafts.

As the only triangulation points which it was practicable to occupy for horizontal angles were all located along the shore-line, and too nearly in a straight line to form figures satisfying

the geometrical requirements, recourse was had, when the depth of water permitted, to water signals, placed back in the marsh, and to flags in the trees on the Pecaniere.

In the construction of water signals, different methods were tried by Mr. Perkins, but he found none so satisfactory as those devised by himself for use on the Florida survey, consisting of a simple tripod, prepared on deck, with a tie-piece connecting the legs at the depth to which it was intended to have them enter the mud, and weighted on each point with about two hundred and fifty or three hundred pounds of old grate-bars. The whole structure, when prepared, being launched from the deck, was swayed down to its bearings by a boat's crew, stationed on cleats nailed to the legs near the water line, and the pole was plumbed afterwards. These signals stood well and maintained their position in water eighteen or twenty feet deep.

In placing signals back in the marsh greater difficulty was experienced. Very light tripods and poles were used, the legs running a couple of feet into the mud, and kept from sinking out of sight by boards laid flat upon the surface and caught under transverse cleats spiked to the legs.

All signal material had to be conveyed overland on the backs of men, or pushed in flat-bottomed boats up the bayous and across the lakes. The high grass and reeds and insecure footing on the floating turf in the former case, and the shoal water and ooze, too soft to support the weight of a man, in the latter, made the labor much more severe than men are ordinarily called to endure.

To the eastward the unsurveyed portion of the coast is apparently quite different in character, and it is hoped that it will present less serious difficulties.

The season was a very trying one, and the success attained is due to the untiring zeal of Mr. Perkins and the officers associated with him, Messrs. E. L. Taney, J. B. Baylor, and G. F. Bird. Subassistant Baylor occupied two magnetic stations, determining the magnetic declination, dip, and horizontal and total intensity at each. One of these was at Morgan City, La., on the banks of Bayou Tigre, east of the town; the other at Light-Horse Station, on Marsh Island, at the southwest pass of Vermilion Bay. Both Mr. Taylor and Mr. Bird were constantly employed on the several operations connected with the triangulation.

The survey included in its limits the principal features of the coast between latitudes 28° 55′ and 29° 55′ north, and longitudes 90° 55′ and 92° 51′ west.

Field-work was closed at the end of May. Following are the statistics of the season as reported by Messrs. Perkins and Taney:

Number of stations occupied for magnetic observations	2
Number of stations occupied for horizontal angles	30
Number of points determined by triangulation	59
Number of pointings made	7,444
Number of miles of shore-line and fast land-line surveyed	368
Miles of shore-line of bayous and ponds	75

Duty assigned to Messrs Perkins and Taney earlier in the fiscal year is referred to under the headings of Sections I and II.

Hydrographic surveys on the coast of Louisiana from Southwest Pass westward, in Barataria Bay and in Coté Blanche Bay.—Under instructions dated December 15, 1885, Lieut. F. H. Crosby, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Gedney, left New York January 18, 1886, having organized his party on board that vessel for hydrographic work on the coast of Louisiana. Arriving at Vermilion Bay early in February, he attempted to get into Coté Blanche Bay without success, and proceeding to Barataria Bay he began off-shore work, for the execution of which he was furnished with two projections, each on a scale of 1–40000, including the coast from Southwest Pass to the lower part of Barataria Bay.

The off-shore work was suspended February 19, and another attempt made to enter Coté Blanche Bay. This was successful and soundings were taken in the bay between March 18 and April 20, when the off-shore work was resumed and continued till the close of the season, May 14.

The hydrography of Coté Blanche Bay was executed on a scale of 1–20000. Lieutenant Crosby had great difficulty in getting his vessel into the bay, and he reports that it cannot be entered with safety by a vessel drawing four feet of water, the entrance from the eastward being full of oyster and shell banks. The deepest water after entering is eight feet, bottom of soft mud. In the winter the water is fresh nearly all the time, being supplied by the Atchafalaya

River. In West Bay, west of the Mississippi River, the water is much shoaler than appears by the last in-shore survey, and the mud flats and stranded drift-wood extend out a considerable distance from the shore-line. In going over the bar at the entrance to Barataria Bay eight feet of water were found at high water.

For the off-shore work west of the Mississippi River Delta, a box-gauge and also a staff-gauge were erected north of Barataria Light-house—the box-gauge with a float and staff-pointer. For the work at Coté Blanche Bay a box-gauge with a rod and pointer secured to the float was erected on the wharf at Coté Blanche Plantation. A plane of reference was established by observing high and low waters for thirty-one consecutive days, and the mean of all the low waters was used.

No current stations were occupied during the season, but it was observed that in Coté Blanche Bay the currents were influenced by the winds and were very irregular. They are also very irregular to the westward of the Mississippi Delta, and cannot be depended upon. Near the shore a vessel will be set to the westward, farther out to the eastward or southeastward, and on going out farther she will again be set to the westward.

Lieut. F. S. Carter, U. S. N., and Ensigns J. S. Watters, G. W. Street, and C. E. Sweeting, U. S. N., were attached to the Gedney.

The statistics of work on the Louisiana coast are:

Miles run in sounding	1,049
Angles measured	5,401
Number of soundings	41,382
Area of hydrography in square miles	342

Other hydrographic duty assigned to Lieutenant Crosby during the fiscal year is referred to under the heading of Section II.

SECTION IX.

TEXAS AND INDIAN TERRITORY, INCLUDING GULF COAST, BAYS, AND RIVERS.

(Sketches Nos. 1, 7, 16, and 17.)

Measurement of a base-line and connection of this line with the triangulation in the vicinity of Brownsville, Tex.—In pursuance of instructions, Assistant R. E. Halter took the field near Brownsville, Tex., in December, 1885, and made the necessary preparations for the measurement of a base and its connection with the triangulation in that locality. The base was measured with steel wire, duly standarded at the office, and corrected for temperature by observations made during the measurement. The length of 5,020 meters was measured twice, the two measures agreeing within 0.015 of a meter. An azimuth was determined at one end of the base, and a connection made with the triangulation on the line Mesena 2–Fronton.

Mr. Halter reports the following statistics:

Number of stations occupied	4
Number of pointings with position instrument	380
Number of pointings on star for azimuth	62
Number of pointings on mark for azimuth	62
Number of observations for time	216

Other work executed by Mr. Halter has been mentioned under the heading of Section II.

SECTION X.

CALIFORNIA, INCLUDING THE COAST, BAYS, HARBORS, AND RIVERS.

(Sketches Nos. 2, 8, 9, 15, 16, and 17.)

Triangulation and topography of the coast of California between Newport Bay and San Mateo.—The survey of the south coast of California was resumed early in July, 1885, by Assistant A. F. Rodgers under instructions dated in the month previous. Camp was pitched in Laguna Cañon, Los Angeles County, and the topographical survey south of Newport Bay was taken up from the limits of work of the last season.

Mr. Rodgers remarks that along the coast between Newport Bay and Aliso Cañon the country is very rough, the hills rising to a height of seven or eight hundred feet within a mile of the shore-

line, and being broken by deep and precipitous gorges. On the 31st of August, this portion of the topography having been nearly completed, camp was moved from Laguna Cañon to San Juan Capistrano, and work begun soon after on a second plane-table sheet.

This locality south of Aliso Cañon and the bold Niguel Ridge, nearly one thousand feet in elevation, is quite remarkable from its being cut up by deep chasms, eroded by the occasional heavy, almost tropical, winter rains. These chasms, or barrancas as they are called, sometimes run bank full in winter, but are dry beds in summer. They are in many places a complete barrier to progress even on foot, and long detours are necessary to cross them. The contours in this locality were found to be extremely difficult to determine, much of the land being a high mesa or table land, with such a gradual slope inland as to make a liberal use of the level expedient. In executing this and other work of special difficulty, Mr. Rodgers had the assistance of Mr. Isaac Winston, Aid, in his party, of whose services he speaks in the highest terms. When not occupied in field-work Mr. Winston computed the triangulation of the previous season, and completed these computations before the party left the field.

In the latter part of October work was finished on the sheet in the vicinity of San Juan Capistrano and begun upon a third sheet towards San Mateo. About one-half of the area included in this sheet had been completed, when, on November 28, in accordance with instructions, it became necessary to close work on the south coast.

On December 2 Messrs. Rodgers and Winston arrived at San Francisco, and from that date till March 8 were engaged in office-work. Two of the topographical sheets of the south coast work were prepared and forwarded to the office; tracings of them were made and filed in the suboffice. Two volumes, descriptions of stations of the south coast triangulation, were prepared, duplicated, and forwarded to Washington.

For the south coast topography, the statistics are:

Miles of roads surveyed	25
Miles of shore-line of creeks	6
Area surveyed in square miles	34

Early in March Assistant Rodgers received orders for field-work in the vicinity of San Francisco, mention of which will be made under a later heading in this section.

Continuation of the series of observations at the magnetic self-registering station at Los Angeles, Cal.—The series of absolute and differential magnetic observations with the Adie magnetographs was maintained at Los Angeles, Cal., without interruption by Subassistant Carlisle Terry, jr., during the fiscal year. The photographic records of the observations were made upon gelatine-bromide paper with great success, a complete record having been kept up with the exception of twenty-nine readings necessarily lost while rebalancing and determining the scale values of the magnets, and seven readings lost on account of a sudden failure of the light from the vertical force lamp.

Scale values of the bifilar magnet were determined on July 1, 1885, and on June 25, 1886. The vertical force magnet was rebalanced on January 4 and March 18, 1886. Its scale values were determined July 1, 1885, and January 4, February 11, March 18, and June 25, 1886.

Observations were made on the 14th, 15th, and 16th of each month to determine the absolute values of the magnetic declination, dip, and horizontal intensity. From these observations the vertical force and intensity were computed.

Time was determined once a month by observations on the sun.

Hourly readings of the unifilar, bifilar, and vertical force traces were made, and the hourly, daily, and monthly means for each month reduced. Abstracts were made connecting the absolute and relative measures, and the mean declination, horizontal, vertical, and total intensity and dip for each month were computed.

All records have been duplicated and all computations and abstracts made in accordance with instructions.

Mr. Terry was assisted in the work of the party by Mr. A. L. Du Puy from July 1 to November 1, 1885; by Mr. W. A. Foster from November 17 to November 30; by Mr. Albert G. Lang from December 1, 1885, to June 30, 1886, and by Subassistant R. A. Marr from February 7 to June 30.

Following is a summary of the various observations made during the fiscal year:

ABSOLUTE MEASURES.

Declination (36 days, 25 observations each)	900
Dip (36 days, 100 observations each)	3,600
Horizontal intensity (36 days, 35 observations each)	1,260
Time (13 days, 24 observations each)	312
Constants of magnet	700

RELATIVE MEASURES.

Scale readings (365 days, 6 observations each)	2,190
Temperatures (365 days, 12 observations each)	4,380
Scale values	1,050

TRACE READINGS.

Unifilar, 365 days	8,832
Bifilar, 365 days	8,828
Vertical force, 365 days	8,800

Reconnaissance for the site of a primary base-line in Los Angeles County, California.—Under special instructions from Assistant George Davidson, in charge of work upon the Pacific coast, Assistant James S. Lawson organized a party to co operate with Assistant Dickins of Mr. Davidson's party, in an examination of Los Angeles Plains, in order to obtain a site for a base-line to be used instead of the preliminary San Pedro Base, one of the terminal markings of which had been maliciously destroyed before 1881.

In compliance with these instructions, Assistants Lawson and Dickins, accompanied by their Aids, Messrs. Morse and Welker, took the field in May, 1886, and made a close examination of the country from Norwalk to Santa Ana Valley (north and south); from Anaheim to Los Cerritos (east and west), and as far as Las Bolsas to the southwest. It was desired by Mr. Davidson to obtain a base-line near the Southern Pacific Railroad between Los Angeles and Anaheim, so as to form one side of a quadrilateral towards Bolsas and San Pedro, and also one side of a quadrilateral towards Santa Anita and San Juan.

Two lines were found, one of thirteen thousand six hundred and fifty meters (8.48 statute miles) in length, running parallel and close to the railroad; its northwest end a short distance south of the village of Norwalk, and its southeast end about a mile from the railroad station at Anaheim; the other seventeen thousand three hundred and ten meters (10.76 statute miles) in length; its north end on a plateau a little over a mile east of the village of Norwalk, and its south end distant two and one-half miles from the Anaheim depot. This line crosses the railroad at an angle of 19° in the immediate vicinity of Coyote Creek.

Plane-table surveys, with measurements, were made of both sites by Messrs. Lawson and Dickins, and the connections of each base with the triangulation are shown upon sketches accompanying the detailed report made by Assistant Lawson. The examinations were most thorough, and will furnish accurate data for a comparison of the relative merits of the two sites.

Continuation of the triangulation and topography of the south coast of California between Estero Point and Point Sur.—Reference was made in the last annual report to the completion of the tertiary triangulation of the south coast of California from Moro Bay westward to the line Irving–Estrada within three miles of the town of Cambria, San Luis Obispo County, by the party in charge of Assistant Stehman Forney.

Under instructions dated in June, 1885, Mr. Forney resumed field-work early in July, and after completing his topographical sheet in the vicinity of Moro Bay, which had been begun the previous season, he took up the triangulation from the line Estrada–Irving, and connected it with the work executed by Assistant Rockwell at San Simeon Bay in 1871–1872.

This done, he left Cambria, October 11, 1885, with his party and pack-train to make a reconnaissance for the tertiary triangulation of the coast fron Piedras Blancas Light-house to Point Sur. Having finished this reconnaissance November 12, he proceeded under instructions to San

Francisco where he was engaged until June, 1886, in working up his field-notes and making the needful computations. On the 12th of June, in pursuance of instructions, he left San Francisco for the field, and at the close of the fiscal year was engaged in completing the topographical survey from Estrada station to the junction of his own triangulation with that at San Simeon Bay in 1871–1872.

Some extracts from the elaborate report submitted by Mr. Forney will be of interest:

"The country between the shore-line and the Coast Range of mountains, running parallel with the shore-line from San Carpojoro to Point Sur is probably the roughest piece of coast-line on the whole Pacific coast of the United States from San Diego to Cape Flattery.

"The highest peaks of the crest of the coast range are located at an average distance from the coast of three and one-half miles. In this distance they rise to elevations of from three thousand six hundred to five thousand feet above the sea-level. From San Carpojoro to Pfeiffer's Point, a distance of fifty-four miles, the shore-line is an iron-bound coast with no possible chance of getting from the hills to the shore-line and back except at the mouths of the creeks and at such places as Coxe's Hole and Slate's Hot Springs, where there are short stretches of sandy and rocky beaches from fifty to one hundred yards in length. In many places the sea bluffs are perpendicular, and rise from one thousand to fifteen hundred feet above the sea. The country is cut up by deep cañons, walled in with high and precipitous bluffs. These cañons are densely wooded with redwook, oak, and yellow and silver pine timber.

"The redwood trees are from three to six feet in diameter and from one hundred to one hundred and fifty feet high. The oaks and pines are of the same average dimensions. Beautiful streams of clear cold water, filled with an abundance of salmon-trout, are to be found in all the cañons. The spurs running from the summits of the range to the ocean bluffs are covered with a dense growth of brush and scattering clumps of oak and pine timber. The chaparral is very thick, and in many places grows to a height of ten or fifteen feet.

"In making a topographical survey through this country it will require a great deal of brush-cutting as well as some cutting of timber to clear lines for the triangulation. The spurs, slopes, and cañons are impenetrable, and trails will have to be cut through the chaparral in order to locate plane-table stations from which to sketch the topography."

Mr. Forney remarks that in his opinion liberal sketching will be sufficiently accurate to show the general topographical features of the country, determining, of course, with accuracy the heights and directions of the spurs and cañons. His report gives many interesting details with regard to the settlements, landings, and anchorages along the coast, and is accompanied by a sketch which shows that his work has developed a direct connection of the chain of tertiary triangles extending from the line Stone–Villa to the line Point Sur–Pico Blanco with the primary triangulation stations Cone Peak, Santa Lucia, Rocky Butte, and Piedras Blancas Light-house.

Occupation of stations in continuation of the primary triangulation of the coast of California, north of Point Concepcion.—In compliance with instructions to resume work in the primary triangulation of California as soon as practicable after the beginning of the fiscal year Assistant James S. Lawson organized his party for the occupation of Castle Mountain early in September, 1885. The condition of the atmosphere previous to that time was such as to make it inadvisable to take the field, although all preparations for a start had been completed. On reaching the foot of the mountain the party found, much to their disappointment, that, owing to the dry summer, all the water supply had disappeared from the site previously selected for the lower camp, and that it would be necessary to select a new site a mile higher up. To reach this with wagons a road had to be graded around a steep part of the hill. The outfit having been removed as rapidly as possible to the new site, the trail to the summit was laid out, cleared, and graded for the pack-animals.

During this time the heat was intense, and the water being strongly impregnated with alkali much sickness resulted. At the earliest moment the instruments and outfit immediately needed at the station were taken up the mountain and the piers and observatory built. On October 6 observations were begun, and on the 31st were finished.

The work at Castle Mountain consisted of observations for horizontal directions, vertical angles, time, latitude, azimuth, and for values of the ocular micrometer of theodolite No. 131 and micrometer of meridian instrument No. 16. For azimuth, α Ursæ Minoris was observed, direct and reflected from mercury.

At the beginning of November, arrangements were made for transporting the party to Hepsedam Station. At the site selected on this mountain for the lower camp many difficulties and dangers were encountered from the sudden rising of the waters in San Luis Creek and the overflowing of its banks caused by sudden and heavy rainfalls. Continuous watching and ditching around the lower camp had to be maintained day and night to prevent the ruin of instruments, equipage, and stores. Another effect of these heavy rains was to render the soil in places so soft that the pack-mules would sink knee-deep in the adobe mud. Attempts were made on several different days to reach the summit, and as often did the animals slip, lose their footing, and roll back to the bottom of the inclines with their packs. Fortunately none were injured, and by watching every favorable opportunity the ascent was finally made. The summit of the mountain is a rocky ledge, offering barely enough surface for the observatory, the foundation for which had to be obtained by great labor in moving large rocks and building them around so as to get space needed. In one respect the party was fortunate, a fine spring of water having been discovered near the upper camp, some three hundred feet below the summit. Mr. Lawson remarks that this is the first time he has obtained water at any of his primary stations without packing it from two to four miles.

The observations at Hepsedam were similar in character to those at Castle Mountain. At each station a sweep of the horizon was made on all surrounding peaks and prominent objects.

Field operations begun at Hepsedam December 12, 1885, were closed January 5, 1886.

During the season Assistant Davidson's party occupied the primary stations, Santa Lucia and Santa Aña, connecting with Castle Mountain and Hepsedam, and in several instances there were stations on which both parties observed. At these one heliotroper attended both instruments.

Assistant Lawson acknowledges in terms of high praise the value of the services of Mr. P. A. Welker, aid in the party. Mr. Welker took some fine instantaneous views in the vicinity of Hepsedam station, copies of which Mr. Lawson has forwarded with his report.

The statistics of the season are:

	At Castle Mountain.	At Hepsedam.
Number of positions of instrument	23	23
Number of observations of horizontal directions	573	603
Number of readings of the ocular micrometer	2,350	2,498
Objects observed, primary and secondary	45	37
Number of o' servations of vertical angles	450	507
Number of observations for time	98	119
Number of pairs of stars observed for latitude	30	30
Number of observations for latitude on eight nights	232	231
Number of observations for azimuth	327	257

Assistant Lawson was engaged with his party in office-work at San Francisco from the close of his field season till early in May, 1885, when he received instructions to take part in a reconnaissance for a base-line site in the vicinity of Anaheim, Los Angeles County, California.

Connection of the triangulation depending upon the Pulgas Base with that depending upon the Yolo Base—Occupation of stations in continuation of the primary triangulation near the southern coast of California.—Assistant George Davidson has continued in general charge of the work upon the Pacific coast, and in virtue of that assignment has submitted to the Superintendent general plans for the prosecution of the land-work in the several sections along the coast; made out detailed instructions to each chief of party, examined estimates and referred them to the Superintendent, and whenever practicable has conferred personally with the Assistants in charge of parties. He has also received and transmitted all of the official correspondence between the Superintendent and the officers of the Survey on that coast.

Mr. Davidson has submitted a comprehensive report of the various operations in which he was personally engaged, or which were carried on under his direction during the fiscal year. These are referred to under the several headings which follow.

Main triangulation and astronomical work.—The connection between the work of 1851–1852 depending upon the preliminary Pulgas Base, and that of later years, depending upon the Yolo Base, was finished by Mr. Fremont Morse, Aid in Mr. Davidson's party, in July, 1885, with quite satisfactory results.

It was found that the triangulation point Table Mount, determined between 1852–1859, differed four feet in latitude from the station Tamalpais of 1876–1882, when in fact both are identical. Mr. Davidson specially traced the history of this discrepancy, and having personally revisited the locality satisfied himself that the two stations were identical, and that the observations at each were wholly trustworthy. He accounts for the change by the effects of an earthquake. On the 21st of October, 1868, occurred the severest earthquake recorded on that part of the Pacific coast; it had its center near Haywards, south of Oakland, and its effects of dislocation were felt many miles more distant than Mount Tamalpais.

On July 15, 1885, Assistant E. F. Dickins joined Mr. Davidson's party, and began preparations for resuming the field-work of the main triangulation in Southern California. The party remained in the field till after the middle of December, having occupied two important stations, Santa Lucia, of about six thousand one hundred feet elevation, and Santa Aña, about three thousand seven hundred feet. The former is very difficult of access. At each station, direction instrument No. 115, diameter of circle twenty inches, was mounted on cement piers with the Davidson position circle. Assistant Dickins made the observations for horizontal directions, vertical angles, and azimuth; Mr. Morse made the transit observations for time, and the zenith telescope observations for latitude, each officer alternately recording for the other.

In this triangulation Mr. Davidson's party worked in such concert with that of Mr. Lawson, whose operations have already been referred to, that at each station occupied, one heliotroper served for signals to both.

After the party left the field the usual office work was accomplished, the records being duplicated, and all abstracts and computations made.

Following are the statistics of field-work for October, November, and December, 1885:

	Santa Lucia.	Santa Aña.	Total.
Horizontal directions:			
Positions	23	23	46
Horizontal measures	516	568	1,084
Ocular pointings	1,548	1,704	3,252
Stations observed	5	5	10
Secondary objects	3	4	7
Vertical angles:			
Stations observed	5	5	10
Secondary objects	1	2	3
Observations	321	363	684
Azimuth:			
Positions	13	13	26
Observations on Polaris	156	156	312
Observations on mark	111	105	216
Ocular pointings	333	315	648
Time:			
Stars observed	21	28	49
Observations	81	103	184
Latitude:			
Pairs of stars	37	26	63
Observations	361	342	703
Micrometer value:			
Pairs of stars observed	2	1	3
Observations	363	183	546

The eighteen volumes of records containing these observations, with the results of the work, were forwarded to the office.

Reconnaissance for the sight of a primary base-line.—Reference has been made in detail under a previous heading in this section to the examinations carried on by Assistants Lawson and Dickins on the Los Angeles plains, having for their object the selection of a site for a base-line to be used instead of the old preliminary San Pedro Base. Of the two sites selected for consideration, Mr. Davidson, under whose general direction the work was done, gives the preference at present to a line of ten and seventy-six hundredths miles in length, crossing the Southern Pacific Railroad at a slight angle. He observes that the country is yet open, and as the improvements are not valuable it is extremely desirable to have the measurement made as soon as practicable.

Examination of stations in the scheme of triangulation, vicinity of San Diego.—Assistants Lawson and Dickins and Aids Morse and Welker made an examination of some of the proposed stations in the scheme of triangulation from San Diego and vicinity northward, and the work was being pushed with vigor when telegraphic orders were received from the Superintendent for its suspension. The party left the field and returned to the suboffice at the end of June.

Observations of the annular eclipse of the sun, March 5, 1886.—The annular eclipse of the sun of March 5, 1886, was observed at the Coast and Geodetic Survey Station, Lafayette Park, San Francisco, by Assistants Davidson and Lawson and Aids Morse, Welker, and Hill.

Mr. Davidson observed with his equatorial of six and one-fourth inches aperture; the observations by his colleagues were made with reconnoitering telescopes having small apertures and low powers.

A tabulated statement of the observations will be found in Appendix No. 6.

Magnetic observations.—To keep up the series of magnetic observations for the purpose of determining the time and amount of the maximum declination on the Pacific coast Mr. Morse was directed to make a regular set of observations for declination, dip, and horizontal intensity at the Presidio Station, San Francisco Peninsula. These observations were made in August, 1885, and again in April, 1886. Reference will be found under the heading of Section XI to similar observations made at stations on the Columbia River.

During August, Mr. Morse reduced the magnetic observations which had been made by Mr. Davidson at El Paso, Tex., and at Tacubaya Observatory in the City of Mexico in 1884. These observations were found of essential value in the discussion of the secular change in the large series of primary stations.

Coast Pilot work.—Whenever the pressure of regular official duties permitted, Mr. Davidson continued the collection of data and material for the Coast Pilot. In his visits to the North Farallones and to Point Reyes he made views and took photographs of these rocky islets. In October he made a trip as far north as Puget Sound for this special duty, and got views and photographs of headlands, &c. Again, in May, on his way to observe in Oregon and Washington Territory, he got other views and photographs. Before he left on this trip the manuscript of the Coast Pilot had been completed as far up the coast as Port Orford. Mr. Ferdinand Westdahl, in the intervals of his regular duty, worked upon a series of views of headlands which he had taken and made a fair copy of the Coast Pilot manuscript.

For the examination of the North Farallones, special authority was obtained by the Superintendent from the Secretary of the Treasury, directing the commander of the revenue cutter Richard Rush to assist Mr. Davidson in this special duty. From four points on the islands which had been determined in 1859, each position occupied by the vessel was established, while soundings, views, and photographs were being taken and heights measured. The soundings showed deep water around these islets, and a twenty-four-fathom passage between the northwestern islet and the mass grouped to the southeast. The islets are barren rocks, reaching one hundred and fifty-seven feet in elevation; too steep to be the home of the sea lion, but covered by myriads of birds. In a special report of this examination, bearing date of May 3, 1886, Mr. Davidson makes a recommendation for a fog-signal on the northernmost of the North Farallones. He acknowledges the cordial assistance of Captain Hooper of the revenue cutter in the work at the Farallones and also in the special examination made by Mr. Westdahl of Noonday Rock. Some discrepancy having been found between the reported position of the rock struck by the ship Alaska and the depth given on

the chart, Mr. Westdahl was instructed to make this examination. The rock which was discovered when the first Noonday Rock was blown away he found again, but observed that the buoy was in a wrong position, and that vessels coming from the northwest would be placed in imminent danger if they made the buoy first. Further examinations will be made.

In October, 1885, upon his return from a tour of inspection, reference to which will be made under the heading of Section XI, Mr. Davidson made to the Superintendent suggestions for Aids to Navigation, and in January supplied more recent information about the location of the Lighthouse on Point Sur.

Suboffice at San Francisco.—Mr. Davidson continued in charge of the suboffice at San Francisco, attended to all the duties, and answered all calls for information.

With the assistance of Messrs. Morse and Hill he computed a second table of the azimuth and apparent altitude of Polaris at different hour angles, and for a large range of latitude, for use in field-work.

Outside of his official duties he was engaged upon the introduction of azimuth and transit stars for his Field Catalogue (Appendix No. 18, report for 1883), so as to enlarge it for a future edition.

He prepared also and nearly completed an extended paper upon the voyages of Ulloa, Cabrillo, Ferrelo, Drake, and Vizcaino upon the coast of California, desiring to locate their positions as far as practicable by studying their descriptions and taking them from his personal acquaintance with the coast. This paper will appear as Appendix No. 12 to this volume.

The observatory at Lafayette Park was used by the Assistants, Subassistants, and Aids for practice and for the determination of the constants of field instruments.

During the greater part of the year Assistant E. F. Dickins was attached to Mr. Davidson's party, and had direction of the details of the work when in the field. He executed all work with satisfaction, both as to character and quantity. Mr. Fremont Morse, Aid, continued in his party throughout the year, was in the field with Mr. Dickins, and did other special field-work. Mr. Davidson commends heartily the thoroughness of his work and his readiness and promptness, both in the field and in the office.

Mr. Ferdinand Westdahl performed duty as draughtsman in the suboffice, and, as already stated, accompanied Mr. Davidson on Coast Pilot and inspection duty. Mr. Charles B. Hill attended to his duties as clerk, made transit observations for time to determine the error of chronometer for the Saucelito Tidal station, and filled all calls outside of official hours. Vicente Denis served as janitor, messenger, and porter, had the care of the instruments and camp equipage in the suboffice, and worked faithfully without regard to hours.

Examination of weights and balances at the United States Mint.—By special authority from the Superintendent, and at the request of the Director of the Mint, Assistant Davidson made a personal examination of all the coin and bullion weights and balances of the United States Mint at San Francisco. This work was done mostly after official hours, and involved a long series of minute observations and checks. The reduction of the observations and the tabulation of the results was done wholly outside of official hours, and necessarily involved considerable time, but it was essentially completed March 30, 1886, at which date it was transmitted, through the Superintendent, to the Director of the Mint.

Under subsequent headings in this and the next section reference will be made to other duty assigned to Mr. Davidson or operations in his charge during the fiscal year.

Shore-line resurvey of Carquinez Straits and San Pablo Bay—Resurvey of the shore-line topography of the Golden Gate and approaches.—A revision of the shore-line of Carquinez Straits and San Pablo Bay having become desirable owing to the changes that had occurred since the survey of 1855, Assistant A. F. Rodgers proceeded under instructions to organize his party for that work, and took the field early in March, 1886. Two plane table sheets were projected, covering the shore-line between Suisun Bay and the south shore of San Pablo Bay at a point about midway between Point San Pablo and Penole Point. These sheets included Carquinez Straits and the entrance to Mare Island Straits. The revision work within the limits named was completed on May 25, after which Mr. Rodgers took up the resurvey of the shore-line topography of San Francisco Entrance

and approaches. This work was continued till June 10, when the exhaustion of the appropriation compelled a suspension of field operations.

From this date to the close of the fiscal year the party was engaged in office-work. The two plane-table sheets including Carquinez Straits and San Pablo Bay, south shore, were in preparation for forwarding to Washington, tracings of them were made for the files of the suboffice, and a tracing prepared showing the progress of the shore-line survey of the Golden Gate.

In both field and office work Mr. Rodgers had the effective service of Mr. Isaac Winston, Aid in his party.

The statistics of this survey are:

Miles of shore-line surveyed	38
Miles of railroads	22
Miles of common roads	22

Tidal observations at the self-registering tide-gauge station, Saucelito, Bay of San Francisco.—The charge of the self-registering tide-gauge at Saucelito, Bay of San Francisco, remained with Mr. Emmet Gray, under the supervision of Assistant Davidson. The tidal and meteorological records from this station for the year are excellent, and almost absolutely continuous. The tabulations and tidal sheets are regularly transmitted to the office after Mr. Davidson's examination of each sheet. Determinations of time for the needs of this work were made by Mr. C. B. Hill at the observatory in Lafayette Park, San Francisco.

Hydrographic survey of the coast of California off Cape Mendocino and to the southward.—The steamer McArthur, under the command of Lieut. E. D. Taussig, U. S. N., Assistant Coast and Geodetic Survey, having been refitted at San Francisco, left that port August 15, 1885, to continue the hydrography of the coast in the vicinity of White Rock station, Shelter Cove, and Cape Mendocino. A tidal observer was left at Westport, Mendocino County, with instructions to keep up tidal observations with the same gauge that had been used during the spring season. On account of the exposed character of the coast, it was not practicable to put up a tide-staff nearer the working ground except at great and unwarranted expense. As a precautionary measure, Lieutenant Taussig landed an extra box, float, and staff, which proved to be of use in the latter part of the season, the first one having been carried away by a heavy swell. On the 10th of November the second one was also carried away during one of the heaviest and most damaging gales ever known on that coast.

The earlier part of the season was devoted to defining the extent of the shoal and banks in the vicinity of White Rock station and Shelter Cove, and the hydrography was completed to a point off Horse Mountain station. The extent of work done was limited, on account of alternate fogs and high winds, very little good working weather having been experienced during the season.

The character of the coast and the necessities of the work then demanded a transfer of the vessel and party to Cape Mendocino, and the survey was prosecuted in this locality, notwithstanding high winds and rough seas, until November 15, when operations were suspended for the season.

Acknowledgment is made by Lieutenant Taussig of the zealous and efficient service rendered by the officers attached to the McArthur: Ensigns Simon Cook, W. L. Burdick, J. A. Bell, and F. A. McNutt, U. S. N. Ensign Burdick was detached November 17.

The season's work is shown upon a hydrographic sheet, scale 1–20000, extending from Cluster Cone Rock to Getchel Creek. Following are the statistics reported:

Miles run in sounding	563
Angles measured	1,720
Number of soundings	8,058

In February, 1886, Lieutenant Taussig was instructed to prepare for resuming and completing the hydrography of the coast between Navarro Head and Cape Mendocino, and in March he was transferred from the command of the McArthur to the command of the Hassler. This steamer he had docked and prepared for sea with all possible dispatch. Leaving San Francisco April 1, he landed a tide observer at Westport, to continue the tide observations at that place as during the

previous season, and subsequently anchored in Shelter Cove to send into the interior for the pack-train required by the signal party and to land the signal party.

Lieutenant Taussig observes that the location of nearly all of the triangulation points on peaks of considerable elevation, the lack of stations on the narrow stretch of beach, and almost continuous bad weather during April, made the work of building signals and establishing them in position one of unusual difficulty, and that this duty was performed by Ensign W. P. White, U. S. N., with commendable zeal and energy.

During April, owing to unfavorable weather, but little hydrographic work could be done. The month of May was favorable and the progress made was satisfactory. From the last week of May till the close of the season, about the middle of June, with the exception of three days of fog, the wind blew a strong northwest gale during all the hours of daylight, but with practice and perseverance some good soundings were generally obtained each day.

Lieut. David Peacock, U.S. N., reported for duty two days before the party left San Francisco. Lieutenant Peacock's skillful use of the Sigsbee sounding machine enabled him to do much work under unfavorable circumstances. Some deficiencies in the parts of this machine were supplied through the courtesy of the Navy Department from the Mare Island Navy-Yard.

The steam-launch Agassiz, under Lieut. C. F. Pond, U. S. N., rendered good service whenever practicable.

On June 13 the main portion of the hydrography was completed, the last soundings being taken on the bank off Shelter Cove, and the Hassler left for San Francisco. Lieutenant Pond was detailed June 14 to run some additional soundings in Soldier's Harbor. On the 18th the Hassler anchored in San Francisco Bay.

In addition to the officers already named, Ensigns J. H. Shipley and C. W. Jungen, U. S. N., rendered acceptable service. April 15, Ensign Shipley was transferred to the McArthur, and Lieutenant Pond from that steamer to the Hassler. Passed Assistant-Surgeon D. O. Lewis and Assistant Engineer Edgar T. Warburton were always ready to give assistance when needed in recording.

Lieutenant Taussig has included in his report very full notes respecting the several landings and harbors within the limits of his hydrographic survey, with descriptions of dangers to be avoided and recommendations for such additional aids to navigation as he deems desirable. On account of the lack of these aids the frequent fogs are sources of great danger to navigators.

For the work of 1886 the statistics are:

Miles run in sounding	629
Angles measured	4,340
Number of soundings	7,572

SECTION XI.

OREGON AND WASHINGTON TERRITORY, INCLUDING COAST, INTERIOR BAYS, PORTS, AND RIVERS.

(SKETCHES NOS. 2, 10, 11, 16, and 17.)

Completion of the connection of the Koos Bay and Umpquah River triangulations—Progress of the topographic and hydrographic survey of the Umpquah River.—In the last annual report an account was given of the operations of the party in charge of Assistant Louis A. Sengteller on the coast of Oregon, between Koos Bay and Umpquah River. Mr. Sengteller had been in the field since May 3, and between that period and the close of the fiscal year had carried the coast triangulation north and south of the Umpquah, had determined all the points needed for the topography and hydrography of that river, and had developed the reconnaissance on the coast to a junction with the line Pony–Simpson of the Koos Bay triangulation.

He was prepared therefore, on July 1, 1885, to begin observations of horizontal angles, and did so by occupying Simpson station. Some delay was, however, caused at the outset by the prevalence of a violent northerly gale, lasting for two days, during which three of his stations were destroyed, and observations upon them, which had been partly completed, were lost. This occurrence led Mr. Sengteller to modify his plan of having observations made from stations at each end of the work simultaneously, and as soon as possible he concentrated the entire strength of his

party at the Koos Bay end, and instituted a regular patrol, whose duty it was to keep the stations well surrounded with brush. Although this had to be packed long distances, it eventually proved an effective safeguard. By August 8, all of the stations had been occupied and a complete junction made between the Koos Bay and the Umpquah River triangulations.

Work was then taken up on the two topographical sheets, which had been projected to include the shore-line of the Umpquah River from its mouth and the approaches northward and southward to the head of navigation for sea-going vessels. Upon the completion of this branch of the survey, October 2, Mr. Sengteller availed himself of the few days of the season remaining to develop the hydrography of the upper part of the river. One week was spent in this duty, the soundings having been carried from the junction of Smith River with the Umpquah down to the latter to about one mile below the Gardiner Mill wharves.

The statistics of the season, which closed October 12, are as follows:

Number of stations occupied in triangulation	39
Number of angles measured	414
Number of observations	7,907
Number of miles of shore-line surveyed	18
Number of miles of creeks surveyed	32
Number of miles of low water line	22
Area surveyed in square miles	11
Number of miles run in sounding	80
Number of angles measured	738
Number of soundings	11,528

Referring to the Umpquah River as the third stream in importance commercially between San Francisco and the Columbia River, Mr. Sengteller renews the recommendations which he has made on a number of occasions since 1883, that the Umpquah River should be buoyed from the bar to Gardiner, and that the entrance on bar buoy should be a whistling-buoy, to enable vessels when approaching the entrance during fogs to *hold on*, as anchorage in ordinary weather is reasonably safe off the bar.

Entering the river and off Winchester Head there is a dangerous reef, bare at low water, with channels at either side. A buoy for that reef is specially needed. Thence to Gardiner, spar-buoys would meet every requisite purpose, and three or four of these would be enough.

Mr. A. W. Fitzgerald served in the party as temporary recorder during the season.

During the winter Mr. Sengteller gave his personal attention to the preparation of the records and reductions of his work for transmission to the archives.

Hydrographic surveys in Tillamook Bay, off the coast in that vicinity, and in the Columbia River.—Lieut. Commander A. S. Snow, U. S. N., Assistant Coast and Geodetic Survey, having organized his party on board the steamer Hassler, left San Francisco, in pursuance of instructions, August 5, 1885, in order to take up hydrographic work on the coast of Oregon. He was directed to give special attention to sounding in the indentation at False Tillamook, with a view of making a careful examination, should it afford an anchorage. At the time that Lieutenant-Commander Snow was in the vicinity, late in August, he reports that although the sea was smoother than usual, and the ship was taken quite close in, there seemed to be no protection from the swell which was then setting from northwest. A boat's party sent to look for Falcon station, on the high bluff marking the bight, returned reporting that no place could be found to effect a landing. The pilot who accompanied the steamer from the Columbia River stated that the indentation at False Tillamook afforded little or no protection as an anchorage, and that he knew of no case when it had been used as such by coasting vessels.

Lieutenant-Commander Snow was informed that with a wind from the northward, or from northward and eastward, the sea is very smooth along the coast from False Tillamook to Cape Meares, and that this was also the case during the brisk northwest summer winds (close in to the coast) when the sea has a more southerly direction. He states, however, that he was not so fortunate as to find any winds from these directions except for such short periods that no diminution of the prevailing westerly swell was caused thereby.

On the afternoon of August 30, the Hassler entered Tillamook Bay to take up a resurvey of that harbor, should it appear from the examinations to be made that a resurvey would be needed. On entering, about an hour before high water, eighteen feet was the least water got on the bar. Parties were sent out on the following day to put up signals, and a tide-gauge was established at the wharf of the cannery, a bench-mark being marked on a rock on the beach a few hundred yards away. Tidal observations were immediately begun and continued day and night for a lunar month, and daily observations afterwards until the conclusion of the work outside.

Lieutenant-Commander Snow states as a general result of such soundings as he was able to obtain in the bay and on the bar that there is need of a resurvey, and that had his instructions warranted taking the risk of a long detention he should have remained to give a more careful examination to the navigable channels inside. But from the day of his entering the bay until the 8th of September the smoke was so dense that no work could be done except on three days during clearing intervals. On the 8th of September the rains commenced and continued with dense fogs until the 17th, the bar meanwhile breaking too heavily to permit any work or to take the ship outside. On that day, a favorable opportunity having offered for crossing the bar, and the danger of being bar-bound inside increasing, owing to the lateness of the season, the Hassler was taken outside to prosecute the off-shore work.

Lieutenant-Commander Snow gives in his report full details in regard to the hydrographic characteristics of Tillamook Bay, and observes that in view of the changes which have taken place in the bay and on the bar, and to meet the wants of the rapidly-growing country around, he recommends a complete resurvey to be made of it, but that this should not be undertaken after the month of August. That from his own experience on the coast of Oregon, and from what he could learn from those familiar with it, he was convinced that any surveying work there can best be done from May to September. The greatest obstacle to be encountered at that season is the smoke from forest fires. The seasons vary greatly, however, in this respect; in the summer of 1884 there was no smoke, and in the summer of 1885 there were very few clear days, but it is only at this season of the year that the sea is smooth enough for boat-work.

Work off the coast was begun with the ship September 17, and, in accordance with instructions, the lines were run about one and a half miles apart, alternate lines, to a distance of twelve miles from the shore, the shorter lines extending only to a distance of eight or nine miles. During the continuance of this work much bad weather was experienced, and it was found necessary to run into Columbia River several times to avoid southeasters which, accompanied by rain and fog, lasted several days. There was also a very heavy westerly swell on the days when work was possible, preventing as near an approach to the coast as was desirable. Heavy breakers, especially in the vicinity of the Nehalem River and Tillamook Bay, rendered any boat-work impossible; there was, in fact, no time during the season when sounding by boats would have been prudent. The coast from False Tillamook to Cape Meares is apparently free from any hidden dangers.

The off-shore lines, beginning in fifteen fathoms of water about one and a quarter miles from the shore, deepened very regularly until a depth of seventy fathoms was reached, twelve miles off, the curves of equal depth running nearly parallel with the trend of the coast. The currents were eccentric, probably because of the changing season, it being a well-known fact along this coast that with the prevailing northwest winds in summer there is a strong set to southward, while in winter the set is more frequently to northward. After southeast or southwest winds, which had prevailed several days, the northerly set was very noticeable.

A survey of Nehalem River Bar, which had been contemplated as part of the season's work (though of minor importance), was found to be impracticable, heavy breakers extending quite across the entrance and to a long distance from the shore. Nor could any definite information be obtained concerning it, the statements made of the depth that could be carried across the bar varying so greatly as to be of no value.

A request having been received from the Light-House Board for surveys to ascertain changes in channels in certain parts of the Columbia River, Lieutenant-Commander Snow was directed to confer as to the details of these surveys with Capt. Charles F. Powell, U. S. Engineers, on duty as engineer of the Thirteenth Light-House District, and on October 13 the Hassler was moved up the river to Walker's Island, where a tide-gauge was established and connected with a bench-

mark at Rainier. Soundings were begun on October 15, using two steam launches, the lines of soundings being run normal to and parallel with the banks of the river and at a distance apart of three hundred feet.

Lieutenant-Commander Snow remarks that the channel now used by ships of deep draught passes close to the Oregon shore near Rinearson station, and is a difficult one because of its narrowness and a sharp turn at this point. The channel is apparently changing so as to make a straighter course possible near the center of the river, still passing to southward of Walker's Island. But for a short distance this channel is yet impracticable at high water for vessels drawing seventeen feet, and even for those of lesser draught it should be well bouyed. A pilot can always be got at Astoria, and no vessel should attempt to pass up or down the river without one, as the channel in many parts of the river undergoes a radical change after the yearly freshets, and after such changes the pilots are accustomed to sound out and buoy the new channel.

Lieutenant-Commander Snow recommends the adoption and issue of "blue prints" as a speedy process of making public the results of new surveys.

The survey of this part of the river was concluded October 20, and the Hassler was then moved down to Astoria for an examination of Aurora channel. For this work tides were observed on Mr. Wilson's gauge at Astoria, a plane of reference having been determined there by a series of observations which had been continued several years. Sounding lines were run as at Walker's Island, three hundred feet apart, parallel to each other and normal to the direction of the channel. This work was much embarrassed by heavy rains, but the channel proper was well developed by October 31, when the survey was closed.

With approval of the Superintendent, tracings were furnished to the Inspector and Engineer of the Thirteenth Light-House District which will sufficiently indicate what changes in buoys are required.

On November 3, 1885, the Hassler left the Columbia River for San Francisco, arriving at the latter port November 8, after a very stormy passage.

The officers attached to the party are referred to in their commander's report as having shown a zeal and energy in the performance of their duties which cannot be too highly commended. They were:—Lieutenant Blocklinger, U. S. N.; Ensigns F. N. Bostwick, W. P. White, J. H. Shipley, and C. W. Jungen, U. S. N.; Surgeon W. S. Dixon, U. S. N., and Assistant Engineer Edgar F. Warburton, U. S. N.

Statistics of the season are as follows:

Miles run in sounding	369
Angles measured	4,242
Number of soundings	9,189

In February, 1886, Lieutenant-Commander Snow was relieved from the command of the Hassler and ordered to command the new steamer Patterson, relieving Lieut. Richardson Clover. Upon taking charge of the Patterson he began, under instructions, to prepare her for service on the coast of Alaska.

Continuation of the hydrographic work in the Columbia and Willamette Rivers.—In pursuance of telegraphic instructions received at the close of May, 1885, and supplemented by written instructions dated June 16, Assistant Cleveland Rockwell organized his party without delay for the continuation of the hydrographic survey of the Columbia and Willamette Rivers.

Under ordinary circumstances he would have begun hydrographic work in the Columbia River near Columbia City, at the limits to which he had previously brought it, but knowing that the river would soon be too high and the current too rapid for sounding, and in order to save transportation, he commenced the work in the Willamette River near the foot of Ross Island at the upper limits of the city of Portland.

In order to obtain a plane of reference for the reduction of soundings his first step was to set up tide-gauges at Vancouver, the mouth of the Willamette, at Saint John's, and at Albina. Several years ago a tidal station was occupied at Vancouver, and the readings of the gauges at the several points were all referred to the Vancouver bench and gauge. Simultaneous observations at each of these stations were made for twenty-four consecutive hours, and as the river was very nearly at a stand, and the fluctuations of level were quite small, this was thought to be sufficient.

Both temporary and permanent bench-marks were established at the mouth of the Willamette, at Saint John's, and at Albina, all suitably marked and described. Later in the season, another bench-mark with tide-gauge was set up on the Columbia at Willow Bar, six miles below the mouth of the Willamette, which was marked and described in the same way.

The work of sounding was then begun, the sloop Kincheloe being moved down the river from time to time as the work advanced. Smoke seriously retarded its progress, it being impossible for many days to see signals across or up and down the river, although above the smoke a bright sun was shining in a clear sky.

Towards the end of September field operations were closed and the Kincheloe laid up at Portland for the winter. The results of the season are shown on three hydrographic sheets on a scale of 1-10000, extending from the foot of Ross Island in the Willamette River to near the head of Bachelor's Island in the Columbia River, a distance of twenty-four miles.

For comparison of soundings, the Coast and Geodetic Survey tide-gauge at Pearcy's Island was connected by simultaneous readings with the tide-gauge of the United States Engineers on the lighted beacon at Three Tree Island.

The statistics of the season are as follows:

Number of bench-marks and tide-stations established	4
Number of miles run in sounding	327
Number of soundings	17,782

During the winter Mr. Rockwell was engaged in reducing his soundings and in plotting and finishing his hydrographic sheets. In May, 1886, he reported under instructions, for field duty, to Assistant George Davidson.

Observations for latitude and azimuth, and for magnetic declination and horizontal intensity, at stations in Oregon and Washington Territory.—During parts of May and June, 1886, Assistant George Davidson occupied the secondary triangulation station Balch, near Portland, Oreg., to determine its latitude and the azimuth of a connecting line of the triangulation. Assistant Cleveland Rockwell was assigned to duty in his party.

Balch is about five hundred feet above the Columbia River, on the lateral spur of a higher ridge, and is reached by a very steep and rough trail, two hundred and fifty-five feet above the road.

For time, the Davidson meridian instrument No. 12 was used. For azimuth, observations were made with direction instrument No. 131, twelve inches in diameter and reading by three microscopes. Observations for latitude were made with the zenith telescope No. 1, and for value of micrometer upon close circumpolars upon two nights.

The statistics of work at Balch station are as follows:

Number of nights of observation for time	18
Number of observations for time	148
Number of nights of observation for latitude	8
Number of pairs of stars observed	24
Number of observations for latitude	160
For azimuth, number of nights	7
For azimuth, number of positions	7
For azimuth, number of observations	173
For horizontal angles, number of observations	56

During the occupation of station Balch, Mr. Davidson made a series of observations for magnetic declination and horizontal intensity at Portland, Oreg., where he had made a similar set of observations in 1870, and where Assistant Lawson had made a similar set in 1881.

In order to determine the latitude of a station and the azimuth of a line in the scheme of triangulation between the Columbia River and Puget Sound, and to have the data obtained available for both the Puget Sound and the Columbia River triangulation, it was decided by Mr. Davidson to occupy Rainier, near the town of Rainier on the left bank of the Columbia River, almost abreast of the mouth of the Cowlitz River. The quadrilateral common to both schemes is Rainier-Rinear-

son, Crawford Ridge-Patton, and station Rinearson, six and a half miles distant, was used as an azimuth station.

The observatory, piers, &c., having been placed in position by Mr. Rockwell, Mr. Davidson began observations for time and azimuth June 21. The work was in progress at the end of the fiscal year. Well-seasoned cedar piers for the instruments were tried at this station, but were found to be much less satisfactory than the brick and cement piers built up at Balch.

Magnetic observations were made at Rainier similar in character to those at Balch.

Inspection of field-work on the coasts of Oregon and of Washington Territory—Reconnaissance for the Coast Pilot.—Under the heading of the previous section reference was made to a tour of inspection of field operations on the coasts of Oregon and of Washington Territory, undertaken by Assistant George Davidson in the autumn of 1885. He took advantage of this tour to obtain data and make sketches for the forthcoming new edition of the Pacific Coast Pilot.

After visiting Assistant Rockwell in October, at Portland and Albina, and satisfying himself as to the amount and good quality of the hydrography executed by that officer during the season which had just closed, Mr. Davidson went to Allan Island, entrance of Rosario Strait, where Assistant Gilbert was encamped. Of Mr. Gilbert's work (referred to in detail under a subsequent heading) Mr. Davidson makes a very favorable report, emphasizing the special value of his work in Deception Pass, which is now used by steamers from Whatcom and Bellingham to Seattle.

On the voyage up the coast from San Francisco, frequent fogs made it difficult to get more than glimpses and partial sketches of prominent points. Near Cape Sebastian sketches were thus obtained. The Columbia River was studied up to Portland. Mr. Davidson remarks that the deep-sea traffic is increasing in an extraordinary manner on account of the great wheat growth of Eastern Oregon and Eastern Washington Territory.

Having examined a station near Portland, at which observations for latitude and azimuth were subsequently made, Mr. Davidson proceeded to Puget Sound, and began an examination of the Sound at Olympia, Wash. At Tacoma he obtained a sketch of Mount Rainier; at Seattle sketches of the same mountain and of the great range of Olympus. He remarks that in the intricacies of the interior navigation, through the waters east of Whidbey Island, views are not of much worth, because some of the channels are very tortuous, and only local knowledge is of use until they are surveyed and buoyed. All through these waters vessels are often compelled to navigate in foggy and smoky weather by the echo of their whistles from the shores, and during the last summer the smoke was for some time so dense that some of the boats were laid up.

Between Port Townsend and Victoria, and thence to Cape Flattery, some views were obtained. From Cape Flattery to San Francisco a southeaster was encountered with dense fog and a current that put the steamer not less than thirty miles out of position. For services rendered by Mr. Davidson in piloting the vessel through the Golden Gate, when surrounded by several other vessels at the same time, he received the thanks of the captain.

With regard to the views demanded for the Coast Pilot by the character of this bold coast, so different from anything on the Atlantic, Mr. Davidson thinks that the coast-line of the whole landfall should be sketched for vessels approaching the coast, and also three views of each head or prominent point, one approaching from the southeast, one from the northwest, and one when abreast.

Triangulation and topography of Possession Sound completed—Completion of the topographical survey of the shores of Snohomish River—Telegraphic determination of the longitude of Tatoosh Island Light.—In August, 1885, at as early a date as practicable after receiving instructions, Assistant J. F. Pratt, having organized his party on board the schooner Yukon, took up the topographical survey of Snohomish River, Washington Territory, from the limits of work of the previous season, and by the 26th of that month had completed it to the head of ordinary summer navigation, which is just above Snohomish City, and which is also the head of tide-water.

The banks of Snohomish River are densely wooded; there is much thick, over-hanging brush, so that in the majority of cases places for plane-table stations had to be cleared. Telemeter forward lines were made the basis of the entire survey of the river.

As the smoky weather, which had prevailed since the beginning of the work, still continued, the topography of Tulalip Bay, on the east shore of Possession Sound, was carried nearly to comple-

tion. On September 8 a southeast gale set in, followed by several days of rain, which dissipated the smoke for the entire season, after which the triangulation and topography were successfully prosecuted, resulting in the completion of Possession Sound, a start in Saratoga Passage, and some progress in Port Susan.

The winter rains having set in on November 3, field-work was closed for the season on the 4th, and the Yukon was then moored in the Duwamish River.

Mr Pratt reports the following statistics:

For the triangulation:	
Number of stations occupied	11
Number of angles measured	147
Number of measurements	5,544
Number of geographical positions determined	28
For the topography:	
Number of miles of shore-line surveyed	21
Miles of river shore surveyed	34
Miles of roads surveyed	9
Area of survey in square miles	38

During the winter and part of the spring Mr. Pratt was occupied at the suboffice in San Francisco in the computations of his season's work, and in May, 1886, proceeded under instructions to Tatoosh Island, at the entrance of the Strait of San Juan de Fuca, to make arrangements for an exchange of longitude signals with Assistant Gilbert, at Seattle.

Through the kindness of Lieut. U. Sebree, U. S. N., inspector of the Thirteenth Light-House District, the party was conveyed to Tatoosh Island by the light-house tender Manzanita, and their equipment and instruments safely landed. All was in readiness for an exchange of telegraphic signals by May 30, but the very poor condition of the telegraph lines made it impossible to get signals for longitude through to Seattle until a repeater had been put into the circuit at Port Townsend. Immediately after this was done signals were exchanged on two nights. Bad weather then set in, and under instructions work was closed. At Mr. Pratt's request, Capt. J. B. Moore of the revenue cutter Wolcott, who was passing in from sea, kindly consented to take the party to Port Townsend.

To Captains Sebree and Moore and to Dr. Thomas T. Minor, president of the Puget Sound Telegraph Company, Mr. Pratt makes acknowledgment for courtesies extended and facilities afforded in the conduct of the work.

Towards the end of the fiscal year he received instructions to resume the survey of Port Susan, and was organizing his party in pursuance thereof at the close of the fiscal year.

Hydrographic surveys in Admiralty Inlet and Puget Sound.—About the beginning of the fiscal year, Lieut. C. F. Forse, U. S. N., Assistant Coast and Geodetic Survey, commanding the schooner Earnest, arrived with his party at Union City, Wash. Ter., under instructions to take up hydrographic work in Hood's Canal. Having set up a tide-staff to get a plane of reference for soundings, the survey of the southern part of the canal was begun and prosecuted at every interval of favorable weather. Towards the end of July and during the greater part of August dense smoke caused by forest fires prevailed, obscuring the signals and making boat-work impossible. September opened with copious rains, clearing away the smoke and enabling the party to resume operations.

On the hydrographic sheet of the southern part of Hood's Canal, the fifty-fathom curve is carried for over six miles, and the twenty-fathom curve extends northeast from Union City about four miles. The shores are bold, and no sunken rocks or other obstacles to navigation exist. The flats off the mouth of the Skokomish River extend out for about a mile, and the water then deepens to from twenty to thirty fathoms. Good anchorage can be found at Union City and to the eastward and northeast.

The part of Hood's Canal under survey was finished September 16, and two days later Lieutenant Forse left Union City for Port Ludlow to finish the gap between Commodore Alden's survey of 1855 and that of later years at Foulweather Bluff, Admiralty Inlet. To save unnecessary delay at this station, the plane of reference established by Lieut. Perry Garst, U. S. N., in 1880, was used, the reading on tide-staff at Port Ludlow corresponding to the bench-mark established by

that officer being determined by tide-levels. Soundings, begun September 24, were carried two miles north of Foulweather Bluff to connect with Alden's survey, including Mutiny Bay. This work was finished October 3.

The plan of work had been arranged so as to provide for hydrographic surveys in Possession Sound, but as it was getting late in the season, and as heavy southeast winds generally prevail during the autumn in and around that Sound, it was thought inadvisable to attempt work in that locality, and it was decided to proceed to Port Orchard and execute the hydrography of that port. Arriving there October 6, sounding was begun October 12. Tidal stations were established in Port Orchard proper, and later in Dye's Inlet, and tidal observations were carried through a lunar month for a plane of reference. The mean rise and fall of the tides was found to be eight and one-tenth feet; the greatest depth reached in sounding was thirty-three fathoms and in Port Orchard twenty fathoms. No dangerous shoals exist and good anchorage can be found almost anywhere.

Field-work was closed on the completion of the survey in that locality, December 4, and the Earnest was laid up in Butler's Cove, near Olympia, Wash.

Ensign J. N. Jordan, U. S. N., was attached to the party throughout the season. Statistics of the work, scale 1—20000, are:

Miles run in sounding	756
Angles measured	6,294
Number of soundings	23,790

Triangulation and topography of Rosario Strait and Burrows Bay—Longitude signals exchanged between Seattle and Tatoosh Island—Beach measurement between Shoalwater Bay and Gray's Harbor.—Instructions to take the field in continuation of the triangulation and topography of Rosario Strait and vicinity having reached Assistant J. J. Gilbert at San Francisco soon after the beginning of the fiscal year, he began to make the preparations needed without delay, and having completed certain indispensable repairs to the launch and scow forming part of the outfit of his party, he left for the field July 23, 1885. After calling at Tacoma for coal and at Seattle for provisions, he reached Burrows Bay and the field of operations on the 27th, and, having established his camp on Allan Island, he began field work August 3.

On account of dense smoke it was possible to observe on short lines only; the triangulation of Burrows Bay was therefore completed before it was clear enough to connect it with the main work. A storm on the 8th of September having cleared the atmosphere, no time was lost in connecting the triangulation, and that done the topography was taken up. The shores on the topographical sheet are mostly rocky perpendicular cliffs, and the work of delineating them was slow and arduous. By October 26 one topographical sheet was finished, and the rainy season having arrived, field operations were soon after suspended for the winter.

While engaged in finishing his office-work, Mr. Gilbert received, in February, 1886, instructions for special astronomical work at Olympia and at Seattle. At Olympia he put up an observatory suitable for observations of latitude and azimuth, and connected the observing station with the triangulation of Budd's Inlet. In May he prepared a new station at Seattle for longitude work in the grounds of the University by permission of the Regents, erecting a suitable building and instrument pier, the station of 1872 having been entirely destroyed by street improvements. Some delay was occasioned by defects in the instrumental outfit and by the bad condition of the telegraph line to Tatoosh Island, but in the end these difficulties were overcome, and on June 12 and 13, by the help of a repeater at Port Townsend, arbitrary signals for longitude were successfully exchanged with Assistant Pratt at Tatoosh and time determinations made.

After closing this work Mr. Gilbert proceeded, under instructions, to Gray's Harbor to make a plane-table and wire connection between that harbor and Shoalwater Bay. During the last days of the fiscal year he was occupied in searching (though without success) for the stations of the old survey, in setting up signals for chaining along the beach, in measuring with subsidiary base bars two lines of one hundred meters each by which to check the length of the hundred-meter wire, and in measuring with the wire nearly eight miles of beach.

This work was in progress at the end of the fiscal year. The statistics of the year's work are:

Number of signals erected	44
Number of stations occupied	33
Number of observations with theodolite	606
Number of geographical positions determined	36
Number of miles of shore-line surveyed	37
Number of miles of roads	11
Area surveyed in square miles	13

SECTION XII.

ALASKA, INCLUDING THE COAST AND ALEUTIAN ISLANDS. (SKETCH No. 12.)

Hydrographic surveys in Southeastern Alaska.—At the opening of the fiscal year, the party of Lieut. Richardson Clover, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer Patterson, had been engaged for about a month in work preparatory to a survey of Clarence Strait, its approaches, and the waters connecting with it in Southeastern Alaska. A base had been measured, a reconnaissance and triangulation completed, astronomical and magnetic observations made, and soundings begun. An account of this work up to July 1, 1885, was given in the last annual report.

Lieutenant Clover has submitted a full report of his survey, accompanied by a sketch showing its limits. Some extracts from this report will be of interest. Referring to the signals used in the triangulation as being of heavy scantling, two and a half by three and a half inches, he observes:

"Even the heaviest signals will not withstand the fierce willy-waws that frequently sweep around these shores. It is a common sight to see avenues in the forests which have been swept out by these willy-waws. I should recommend the use of the lightest scantling, and that large signals be built in pyramid form and covered entirely with white sheeting. Whitewash does not cover sufficient surface and will not stand the frequent rains, for it is not likely to get a chance to harden before it is rained on. Twenty yards of sheeting at a cost of one dollar to each triangulation signal would in the long run be great economy."

And with regard to the nature of the work, the means available for executing it, the people, climate, &c.:

"The hydrographic characteristics of the country are deep water and isolated rocks, which rise up in unexpected localities. The average depth of the main channels exceeds two hundred fathoms, and to have sounded out the whole field by the old system of heavy lead and line would have been very laborious, and would of itself have consumed about all the time of the party for the season. Before leaving San Francisco I had made composition hand-reels and stands for sounding with piano wire, to be used in the launches. The counting registers were made on board by Passed Assistant Engineer H. N. Stevenson, U. S. N. These reels proved to be of the greatest service, and when mounted in one of the Herreshoff steam launches we were able, when moving at a speed of eight knots, to stop dead, sound in two hundred fathoms, reel up, and be moving ahead again, full speed, inside of six minutes. Thus the launches were much better suited for the deep sounding than a large vessel would be, particularly as by immediately reversing the engine they can be brought to a dead stand in only their length while moving at full speed, and need no time to regain headway. For ordinary work I found a seven-pound hand lead sufficiently heavy.

"The topographical features of the country are exceedingly monotonous. While much has been said of the commercial value of the timber, I found as a rule that the trees in the immediate section grew to a great size, usually from forty to sixty feet, and close together. There is but little depth to the soil covering the rocks of the mountains, and consequently the trees immediately show want of nourishment in a dry spell. Their roots have so little hold that frequently willy-waws sweep out whole avenues in the forest. The yellow cedar was found, but never in sufficient quantities to make any particular locality valuable. They are also said to be usually rotten at the core, so they do not cut up well. Gold and silver bearing quartz was frequently found on Gravina

Island and about Moira Sound, but it is an exceedingly difficult country in which to prospect. Copper ore is also found.

"There was no trouble in keeping supplied with a variety of fish. Crabs are very abundant, also a delicious small clam resembling the eastern Little Neck clam. No oysters were found. Venison was easily procured, but small game was scarce.

"This section is sparsely inhabited by the Hydah Indians, the best type of the Alaskan nation. Howkan and Kassan are about the only villages from Dixon Entrance up Clarence Strait to Earnest Sound; much less than a thousand people in the whole section. They live in the villages in the winter and scatter in their canoes in the summer to the fisheries, some of them going for a week as far south as Puget Sound.

"The climate I found very pleasant and healthful, judging from a summer that was said to have been exceptionally fine. * * * As a rule in the summer, a southeast gale, lasting three days, may be looked for once a month, while in the winter these gales are said to be frequent and very severe."

Lieutenant Clover has included in his report barometric and thermometric means, and maxima and minima during the time of his stay. Of the whole number of days, one hundred and twenty-three, there were fifty-three on which rain fell, twelve on which fog prevailed more or less, and fifty-eight that were either clear, overcast, or hazy or smoky.

Between May 17 and September 16, the dates of arrival and of closing respectively, the work accomplished included all the operations incident to the triangulation, shore-line topography, and hydrography of Clarence Strait from Cape Chacon and Dall Head on the south to Narrow Point and Union Bay on the north. Also the shore-line topography and hydrography of Dixon Entrance from Cape Chacon to Cape Nuzon, with the exception of Cordova Bay.

The officers attached to the Patterson and the special branches of work assigned to them by their chief were as follows:

Lieut. J. M. Helm, U. S. N., executive officer.
Subassistant R. A. Marr, Coast and Geodetic Survey, astronomical and magnetic work.
Ensign Walter McLean, U. S. N., tides, &c.
Ensign C. C. Marsh, U. S. N., triangulation.
Ensign A. P. Niblack, U. S. N., topography.
Ensigns D. P. Menefee and T. G. Dewey, U. S. N., hydrography.

Lieutenant Clover expresses his hearty appreciation of the party as a whole, and makes special acknowledgment of the services of Lieutenant Helm, upon whose energy and watchfulness so much depended, and of the able and efficient services of Ensigns Marsh and Niblack and Mr. Marr.

The following stations were occupied for astronomical work during the season: Port Townsend, Wash. Ter. (as a base station and point of reference for longitudes); Port Simpson, British Columbia; and in Alaska, Ward Base, Point Nunez, White Rock, Peti Signal, Red Signal, Tolstoi Bay, Union Bay, Peninsula Point, Naah Bay, Howkan village, and Kai-gah-nee village. Telegraphic longitude signals were exchanged between the station at Port Townsend, Wash. Ter., and the observatory at Mare Island Navy-Yard, California, at the beginning and at the close of the season. Magnetic observations were made at Union Bay and Peninsula Point, Alaska, and at Port Simpson, British Columbia.

Five tidal stations were established and tides observed on one hundred and two days. Five current stations were occupied and observations of currents taken on twelve days.

The general statistics are as follows:

Miles of shore-line surveyed	979
Miles run in sounding	2,340
Number of soundings	12,997
Area of survey in square miles	2,025

After coaling at Departure Bay, British Columbia, the Patterson arrived at Port Townsend, Wash. Ter., on the 24th of September, left there October 2, and made the run to San Francisco in thick fog in the quick time of ninety hours.

In February, 1886, Lieutenant Clover received orders detaching him from duty on the Coast and Geodetic Survey on the reporting of his relief, Lieut. Commander A. S. Snow, U. S. N. In March following, the continuation of the survey of the coast of Alaska was assigned to this officer, with the command of the steamers Patterson and McArthur, Lieut. J. M. Helm, U. S. N., commanding the McArthur, having been directed to report for duty under Lieutenant-Commander Snow's direction.

On the 1st of May the two steamers arrived at Port Simpson, British Columbia, on their way to resume work on the Alaskan coast. At the date at which this report closes a survey of Sumner Strait, Southeastern Alaska, was in progress; a base-line had been measured a short distance south of the trading settlement, known as Fort Wrangell, on Wrangell Island; the north end of the base had been occupied as an astronomical station, and a topographical survey of Fort Wrangell completed.

More detailed accounts of Lieutenant-Commander Snow's work are necessarily deferred till the next annual report.

Series of tidal observations with self-registering tide-gauge continued at Saint Paul, Kadiak Island, Alaska.—The tidal record at the self-registering tide-gauge station, Saint Paul, Kadiak Island, Alaska, has been continuous, with a few breaks, when the range of the tide was excessive. But the present observer, Mr. Fred. Sargent, has made every effort to correct the sources of trouble. The tabulations and original sheets are received through the trading ships. Assistant Davidson, who has general supervision of the work, again acknowledges valuable assistance afforded to the observer by Mr. Ivan Petroff, Deputy Collector of Customs at Saint Paul.

SECTION XIII.

KENTUCKY AND TENNESSEE. (SKETCHES Nos. 1, 4, 5, 14, 16, and 17.)

Extension westward of the primary triangulation and reconnaissance near the thirty-ninth parallel in Kentucky and Ohio.—Under the heading of the next section, a full abstract will be given of the operations of the party of Assistant A. T. Mosman in carrying to the westward the primary triangulation and reconnaissance near the thirty-ninth parallel in the States of Kentucky and Ohio.

In the progress of this work, stations were occupied in both States, and the reconnaissance for additional stations was extended westward from the line Cherry Ridge, Ky.–Peach Mount, Ohio.

Geodetic operations—Occupation of stations and reconnaissance in continuation of the triangulation of the State of Tennessee.—Prof. A. H. Buchanan, Acting Assistant, was in the field, in pursuance of instructions, at the opening of the fiscal year, and began his work in continuation of geodetic operations in the State of Tennessee by the occupation of Brushy station. On account of bad weather, observations here were not completed till late in September. The occupation of Cockspur station, which was finished October 24, completed the work of the season. Both of these stations are in the eastern part of the State, between the Cumberland range and the Great Smoky Mountains.

Under instructions received early in June, 1886, a reconnaissance was begun for extending the triangulation westward from Nashville.

Professor Buchanan reports that the scheme of triangulation connecting Nashville and Knoxville is now complete.

The statistics are:

Horizontal angles, number of observations	1,982
Vertical angles (double zenith distances), number of observations	1,738

SECTION XIV.

OHIO, INDIANA, ILLINOIS, MICHIGAN, AND WISCONSIN. (SKETCHES Nos. 1, 4, 13, 14, 16, and 17.)

Extension westward of the primary triangulation and reconnaissance near the thirty-ninth parallel in Ohio and Kentucky.—Having organized his party under instructions early in July, 1885, Assistant A. T. Mosman took up the extension westward of the primary triangulation near the thirty-ninth parallel in Ohio by the occupation of station Gould, a point about a mile east of Franklin Furnace, Scioto County.

In order to expedite the work, Mr. Mosman had planned to occupy two stations about the same time; hence at some stations two heliotropers were necessary. While he was preparing Gould station he sent Mr. W. B. Fairfield, extra observer, to visit the stations to be observed upon, adjust the signals, and post the heliotropers when needed.

Camp was ready at Gould July 15, and observations were begun July 19. On July 29 Mr. Fairfield occupied station Fradd, about ten miles northeast of the town of Ironton, Lawrence County. Observations at this station were finished August 14, and at station Gould all observations of horizontal directions had been completed by August 5. This being an astronomical station also, determinations of time, latitude, and azimuth were begun as soon as the necessary instruments could be received from the office, but owing to events there which led to delay, and on account of unfavorable weather, observations for time could not be obtained till August 23. Very rainy and cloudy weather prevailed till September 11, but by the 18th of that month the work at Gould was finished.

Between August 26 and September 8, two stations, Cave and Howland, were occupied in Kentucky, both in Greenup County. A signal had previously been erected at Round Top, a conspicuous hill of some seven hundred and fifty feet elevation, called by the river pilots the highest point on the river between Pittsburgh and New Orleans.

On September 19, observations having been completed at all stations that could be occupied before extending the reconnaissance, the astronomical instruments were forwarded to the office and arrangements made for storing the camp equipage at Franklin Furnace. This done, all hands were discharged except the driver, and Messrs. Mosman and Fairfield began a reconnaissance for the extension of the triangulation westward from the line Scioto (Ohio)–Round Top (Kentucky).

Mr. Mosman observes that this country is a very difficult one for obtaining long lines of sight, being formed of ranges of steep hills, all densely wooded and all of about the same elevation. The stations Scioto, Round Top, Twin Creek, and Peach Mount, Ohio, and Cherry Ridge, Kentucky, were visited, and by October 4 the line Scioto–Peach Mount had been cleared of timber, so that a signal fifty feet high at Peach Mount would render this line intervisible, a tripod one hundred feet in height having been erected at Scioto. To obtain this line of eighteen miles in length, lines were opened through heavy timber a mile and a half long and crossing over the tops of five ridges.

During the progress of this work Mr. E. E. Torrey, foreman in the party, had erected an observing tripod and scaffold eighty feet high at Twin Creek, which was finished October 10. The line from Scioto to Twin Creek was then opened and preparations made for the simultaneous occupation of Scioto and Round Top, Mr. Mosman and his foreman being at Scioto and Mr. Fairfield and a recorder at Round Top. The first-named station is three miles northwest of Portsmouth, Ohio, the second about five miles eastwardly of Vanceburg, Lewis County, Kentucky.

Between October 21 and November 30, observations at these two stations were finished, and on December 1 a station was occupied at Springville, Greenup County, Kentucky, in the extreme northeastern corner of the State. At this station, as at Scioto and at others occupied during the season, observations were made on spires of churches, court-houses, and other public buildings whenever practicable, to fix them in geographical position. At the request of the County Commissioners a meridian line was laid off in the grounds of the Children's Home, at Portsmouth, Ohio.

On December 4 the party started down the Ohio River to Ripley, Brown County, to extend the reconnaissance westward from the line Cherry Ridge (Kentucky) to Peach Mount (Ohio). Very cold and thick weather set in at this time; still one very good figure was obtained, reaching about twenty-two miles westward in Ohio and Kentucky to a line Ashridge–Minerva. But the weather had now (December 20) become too unfavorable to prosecute the reconnaissance to advantage, and on December 25, at Portsmouth, Ohio, the party was disbanded.

The statistics of the season are as follows:

Primary stations occupied	6
Secondary station occupied	1
Number of observations of horizontal directions	2,835
Number of results for latitude	126
Number of pairs of stars observed	18
Number of measures for azimuth	230

Mr. W. B. Fairfield, extra observer, served in the party throughout the season, making all of the observations of horizontal directions at five of the stations, aiding in the reconnaissance, and in all capacities rendering valuable service. Mr. J. W. Dudley was attached to the party as recorder from July 16 to August 31. Mr. P. A. Mosman served as foreman very acceptably till September 24, when he left the party, and his place was supplied by Mr. E. E. Torrey, who served faithfully till the close of the season.

Mr. Mosman was engaged in completing the records and results of his work till towards the end of March, when he was assigned to duty at the office.

Occupation of stations for continuing the triangulation of the State of Ohio.—In accordance with plans submitted to and approved by the Superintendent, R. S. Devol, Acting Assistant, organized his party for continuing the triangulation of the State of Ohio at the beginning of the fiscal year.

After having made the necessary inspection and adjustment of signals, he occupied Barton station, about eight miles southwest of the town of Logan, in Hocking County. Observations at this station had been partly completed the year before; hence but a few days were required to finish the work here, and on July 15 the party was transferred to station Cook, about four miles to the east of Logan. The completion of observations at Cook, and the partial completion of those at station Schultz, four miles south of Logan, closed the work of the season, the allotment of funds having become exhausted August 26.

Stations Schultz, Cook, Brown, Buck Hill, and Gibson were suitably marked and described.

All of the records of the field-work, including the morning and evening readings of the aneroid barometer, which were kept up as heretofore at each station, have been sent to the office. The total number of angular measurements was twelve hundred and fifty-six.

Extension to the eastward in the State of Indiana of the transcontinental triangulation near the thirty ninth parallel.—Instructions issued to Assistant George A. Fairfield in June, 1885, directed him to resume work on the transcontinental triangulation in Indiana as soon after the 1st of July as practicable. By supplementary instructions, issued early in August, he was directed to connect the astronomical station at Vincennes with the primary triangulation.

Preliminary arrangements were begun by Mr. Fairfield July 1. At that date he dispatched his foreman to put up the necessary signals, and on the 6th of the month left for Washington, to obtain instruments, preparatory to occupying Summit station, about nine miles northwest of Vincennes. All preparations were made at the station, but delay occurred in beginning the work, owing to imperfections in the theodolite, which could not be remedied except by returning it to the office. Events there quite unforeseen in their nature led to further delay, so that it was not till the 8th of August that the instrument was received in good order.

In the mean time Assistant J. B. Weir, who was attached to the party, had made a reconnaissance for the purpose of connecting the Court-House at Vincennes, to which the astronomical station had been referred, with the main triangulation. This work was found to be quite difficult, owing to the rolling character of the country and the height of the trees on all of the elevations.

Observations were begun at Summit station August 11, large tripod and scaffold signals having been erected by the foreman at two of the stations to be observed upon. As during several previous seasons, the observations for horizontal directions were made at night, by using at the several stations student-lamps fitted with reflectors, so as to be effective for night signals. The only exception was at Claremont station, in Illinois, thirty-four miles west of Summit. From Claremont it was found necessary to have a magnesium light shown, the student-lamp reflector not being bright enough.

On the 6th of September all of the observations at Summit station were completed; the observations at the "Court House" and at "Wolf Hill" for connecting the astronomical station at Vincennes with the triangulation had been made, and on the 12th of the month camp was pitched at Merom, Sullivan County.

The point to be occupied at Merom was in the cupola of the college building in that town, and much work had to be done before the theodolite could be mounted there. Observations at Merom were finished October 2, and the party was then transferred to station Sisson, which is on the road from Carlisle, Sullivan County, to Pleasantville, about seven miles from the former place and two

miles from the latter. Camp was pitched and the signal lights were posted, but owing to bad weather observations were not begun until October 16. At Calvary station it was found necessary, in order to avoid cutting, to build a superstructure thirty feet high on top of the tripod already erected there; this made the elevation of the signal light one hundred and five feet. Work at Sisson station was finished November 5, and the party soon after disbanded.

The statistics of the season are:

Number of tripod and scaffold signals erected (1 of 80 feet, 2 of 75 feet, 1 of 105 feet)	4
Number of primary stations occupied	3
Number of secondary stations occupied	2
Number of observations for horizontal directions	1853

Assistant John B. Weir was on duty with the party during the season; Mr. F. P. Bacon served as recorder, and Mr. E. E. Torrey as foreman from July 1 to October 17, at which date he was sent to join Assistant Mosman's party. Mr. Fairfield acknowledges the interest shown by all the members of his party in bringing the work to a successful close, and refers especially to the value of the services rendered by Mr. Weir.

During the winter, Mr. Fairfield was occupied at the office in completing the records and results of his field operations. Upon finishing that work, he was first assigned to regular duty in the office and then transferred to the party of Assistant Henry Mitchell.

Geodetic operations—Continuation of the reconnaissance and triangulation of the State of Indiana.—Reference was made in the last annual report to the resumption of geodetic operations in the State of Indiana by Prof. J. L. Campbell, Acting Assistant, at the opening of the season in 1885. Twenty days in the month of June in that year were occupied in the location of station O and M (one of the stations of the third quadrilateral north of the Ohio River) and in the construction of a tripod and tower at that station.

During July, August, and part of September four stations were occupied for the extension of the triangulation, namely: Six Mile, Haystack, Lutz, and O and M. At the two latter stations observing tripods and scaffolds forty and forty-five feet in height were required; at the two former the observations were made from the ground. Stations Six Mile and Haystack, and also the advanced stations Bartle and Summit of the last quadrilateral of the reconnaissance, are on spurs of "The Knobs," while stations Lutz and O and M, with a new advanced station (x), not yet fully determined, are on the dividing ridge between the waters of Silver Creek, west, and the Ohio River, east.

The elevations of the stations occupied above sea-level, as determined approximately by referring them to the nearest railway stations, and by means of the railway profiles, access to which was accorded to Professor Campbell, are as follows: Six Mile, nine hundred and thirty-seven feet; Haystack, nine hundred and seventeen feet; Lutz, six hundred and five feet; and O and M, six hundred and ninety-nine feet. Each station was referred also in location to the section corners of the Government Land Surveys.

At the four stations occupied fifteen principal angles were measured. For the determination of these angles the number of observations made was one hundred and eighty-two and the number of pointings one thousand and ninety-two.

Field-work was suspended September 15. In December, Professor Campbell occupied five days in reconnaissance for a new station north of O and M, and in May, 1886, he was authorized to use a small unexpended balance of the allotment for his work to continue the reconnaissance.

Prof. J. M. Coulter served as recorder in the party. It was but for a brief season that the reconnaissance could be prosecuted in June, 1886, the work being closed under instructions June 30, in consequence of the failure of the House Appropriations Committee to insert the usual item for aid to State surveys in the Sundry Civil Expenses bill.

Determinations of gravity at Ann Arbor, Mich., and at Madison, Wis.—Reference was made under the heading of Section II to the plan for carrying on gravitation work during the fiscal year as outlined in instructions received by Assistant Charles S. Peirce in July, 1885, and to his selection of stations at Ann Arbor, Mich., and Madison, Wis., among others, for swinging the two

invariable reversible pendulums, one a yard, the other a meter in length. After being oscillated at the western stations, these pendulums were remeasured and oscillated at the Smithsonian Institution.

Reductions of the observations at Ann Arbor were carried towards completion, and reductions of those at Madison begun. At both of these stations time signals were kindly supplied by the Directors of the Observatories.

Magnetic observations at Detroit, Mich.—Reference has been already made in this report to the occupation of a number of stations by Subassistant James B. Baylor for the determination of the magnetic elements, this duty being executed under instructions issued in July, 1885. At Detroit, Mich., a station was selected in the grounds of the Harper Hospital, at which observations were made for magnetic declination, dip, and intensity. A comparison of Mr. Baylor's results with those obtained at Detroit by the U. S. Lake Survey at various periods between 1859 and 1876 will furnish additional data for the value of the secular change of the magnetic elements in this locality.

Geodetic operations—Continuation of the triangulation of the State of Wisconsin.—Prof. John E. Davies, Acting Assistant, has transmitted his report of field-work in advancing the triangulation of the State of Wisconsin during the fiscal year. He has taken occasion in this report to review the history of the origin and progress of the survey under his charge, stating the considerations which led to the adoption of the scheme according to which the work has been developed.

Professor Davies reports the completion of the connection of his triangulation with that of the U. S. Lake Survey at stations Erin, Delafield, and Lebanon, and remarks that while the work was one of considerably greater difficulty than he had anticipated, it proved very satisfactory, the results showing that the triangulation of the State, as far as he had carried it, agreed well with that executed by the U. S. Engineers with much more refined appliances.

The work of the season of 1885, which began July 7, was somewhat retarded by the loss of all the records and papers of former years in the fire at the University of Wisconsin the previous winter.

It was found necessary also to revisit many of the stations and to rebuild some of the signals. A tripod and scaffold signal was begun at Medina station, and preparations made for the re-occupation of station Pleasant Springs in order to get measurements upon Harmony and Janesville stations, which had not been selected when Pleasant Springs was first occupied. Very variable weather with violent storms prevailed during the month, and delayed the completion of the work at Pleasant Springs till August 1. In August, in anticipation of the occupation of Medina station, near Marshall, Dana County, Wisconsin, a tripod and scaffold signal sixty-five feet in height was built at Reeseville, and one of seventy feet at Minnesota Junction, one of the latitude stations of the U. S. Lake Survey.

Observations were continued at Medina station till September 5, when the party was transferred to Lowell, near Reeseville, Dodge County. Field operations were closed for the season at Lowell station, September 14. Professor Davies reports the following statistics:

Number of signals erected and repaired	7
Number of tripod and scaffold signals erected	3
Number of separate measurements of angles	129
Number of repetitions	1548

In June, 1886, he took up a reconnaissance for extending the triangulation westward from stations Minnesota Junction, Lebanon, and Delafield.

Observations for latitude at Madison, Wis.—Reference was made in the annual report of the Superintendent for 1873 to the determination of a point in the grounds of the University at Madison by observations of latitude and longitude, the observations being made by Assistant F. Blake. At that time the Madison Observatory had not been established. Soon after its operations began it was found that a discrepancy existed between the latitude as determined by observations with the instruments of the Observatory and the latitude of the Coast Survey station as referred by the measurement to that of the Observatory. This discrepancy may be due to a want of the best determinations of star places in some of the pairs observed for latitude, or to some errors in the values of the instrumental constants employed in the reductions. It was

deemed advisable, therefore, to take as early an occasion as practicable after a result had been reached from the several methods of determining the latitude of the Observatory to obtain a new determination, using the same pairs of stars at the Coast Survey station and at the prime vertical pier of the Observatory as had been used in 1873.

This duty was assigned in July, 1885, to Subassistant F. H. Parsons, the Director of the Observatory, Prof. Edward S. Holden, having expressed his wish to have the work done and having offered his co-operation.

Observations for latitude were accordingly made by Mr. Parsons at the two stations named with zenith telescope No. 5, on fourteen nights between July 30 and August 26. The records, original and duplicate, have been transmitted to the office.

Other duty assigned to Mr. Parsons is referred to under the heading of Section XV.

SECTION XV.

MISSOURI, KANSAS, IOWA, NEBRASKA, MINNESOTA, AND DAKOTA. (SKETCHES NOS. 2, 14, 16, AND 17.)

Extension westward of the primary triangulation in Missouri and Kansas near the thirty-ninth parallel.—Arrangements were made by Assistant F. D. Granger, in accordance with instructions, to resume work in Missouri on the transcontinental triangulation at as early a date as practicable after the beginning of the fiscal year.

During the previous season the triangulation had been brought up to the lines Fulton–Berry and Bowler–Berry, stations in the western part of Missouri. A tripod and scaffold observing station sixty feet high had been erected at station Haskin in Kansas, and lumber for a signal of the same height at station Marty in Kansas had been purchased. Lumber was also on the ground at two other stations for the erection of tripod and scaffold signals; hence Mr. Granger was able to take the field without delay for the erection of signals, and to settle definitely the intervisibility of some points, determined by the reconnaissance made in 1881, and between which were groves of valuable trees. It was found fortunately that the lines of sight passed sufficiently above the intervening trees so that they were not affected by the variable refraction and generally disturbed atmospheric conditions noticeable in making observations near the surface of the ground.

On the 28th of July, camp was pitched near station Marty in Kansas, about nine miles in a southwesterly direction from Kansas City, Mo., and observations were begun August 1. The theodolite was mounted upon the tripod of the signal at an elevation of sixty-four and three tenths feet. From this station, five primary, two secondary, and twenty tertiary directions were determined, and observations for differences of heights were made upon the principal objects. On August 20, the work at Marty having been finished, the camp and party were transferred to station Haskin, eighteen miles to the southward, and eight miles to the east of the town of Springhill, Johnson County, Kansas. The elevation of the theodolite at this station was sixty-four and six-tenths feet. Five primary and nineteen tertiary objects were observed. Upon the completion of observations at Haskin, a station was occupied at Bebe Mound, about three miles west of Edgerton, Johnson County, Kansas. At this point, which is the most prominent one in the locality, the observations were made from an elevation of fifty-five feet. Four primary and ten tertiary directions were observed. With a view to the extension of the scheme, vertical and horizontal measures were also made upon the most prominent and distant objects to the westward.

Station Thomas, about six miles southwest of Olathe, Kans., was next occupied. Five primary and thirteen tertiary objects were observed, the theodolite being mounted upon the tripod at an elevation of fifty-four and six-tenths feet. Upon closing the observations at Thomas, October 22, a portion of the camp was stored at Olathe and preparations were made for transferring the party to Eckman, Leavenworth County, Kansas, the last point in the scheme ready for occupation. Here the theodolite was elevated fifty and five-tenths feet above the ground, and the observations upon five primary, one secondary, and sixteen tertiary objects were all made by Subassistant E. D. Preston.

During the season, Mr. Preston, in addition to making the observations at Eckman, occupied with a six-inch repeating theodolite three points, selected by him on the Missouri and Kansas State line; re-occupied station Berry for observations upon the State-line points, and observed a

series of angles from the Court-House at Independence, Mo., for the determination in geographical position of the Second Presbyterian Church, Kansas City, which had been referred by the longitude party to the astronomical station. The greater part of the observations of double zenith distances were also made by Mr. Preston. His efficient services are commended in Mr. Granger's report.

The statistics of the season are:

Number of observations of horizontal angles	544
Number of observations of horizontal directions	2,646
Number of observations of micrometric differences	908
Number of observations of double zenith distances	211

The positions of the three points determined on the Missouri and Kansas State line were furnished to the Geological Survey.

During the winter and part of the spring following, Mr. Granger was engaged in completing the records and results of his field-work, and was subsequently assigned to regular duty in the office.

Differences of longitude by telegraphic signals between Kansas City, Mo., Ellsworth and Wallace, Kans., and Colorado Springs, Colo.—Latitude observations at Ellsworth and Wallace.—At the beginning of the fiscal year the longitude parties were assembled at Kansas City, Mo., for the purpose of observing for personal equation and re organizing for the continuance of the work to the west.

During the last days of June, personal equation observations had been made by Assistant Edwin Smith and Subassistant E. D. Preston. During the first days of July, Mr. Preston observed personal equation with Assistant C. H. Sinclair. Mr. Preston was then relieved from duty on longitude work, and Messrs. Smith and Sinclair continued office-work till July 14, when, under instructions, the parties were organized for the work of the season between Kansas City and Colorado Springs, Kansas City and Ellsworth, Kans., and Ellsworth and Wallace, Kans.

The charge of one of the longitude parties was assigned, July 21, to Assistant George W. Dean, with the aid of Assistant Sinclair. This party occupied a station at Kansas City, Mo., in the grounds of the Franklin School. The party in charge of Assistant Edwin Smith established a station at Colorado Springs, Colo., to the west of the Antlers Hotel and about four hundred feet south of the station of 1873.

Exchanges of signals by telegraph for difference of longitude of Kansas City and Colorado Springs were had on the nights of July 28, August 2, 4, 5, and 7, after which the observers, Messrs. Smith and Sinclair, changed stations, and similar exchanges were had on the nights of August 12, 13, 14, and 15.

Upon Mr. Smith's arrival in Kansas City, Mr. Dean proceeded to Ellsworth, Kans., to prepare an observing station, and was joined there by Mr. Sinclair after the completion of the work between Kansas City and Colorado Springs. Some delay occurred after the completion of the station at Ellsworth, owing to the non-arrival of the instruments to be used there, which had been forwarded from Omaha. Before exchanges of signals were obtained, Mr. Sinclair was transferred to duty in charge of the West Virginia and Pennsylvania boundary survey, and Subassistant F. H. Parsons was ordered to Ellsworth in his place. The difference of longitude between the station at Ellsworth, located in the grounds of the public school, and the Kansas City station was determined, in the first position of the observers, on the nights of September 8, 10, 13, 14, and 15, after which the observers changed places, and similar determinations were obtained on September 16, 17, 18, and 19.

For the latitude of the station at Ellsworth seventy-six observations were made on twenty-one pairs of stars on nine nights.

On September 18 Assistant Dean was relieved from duty in connection with longitude work. Mr. Parsons proceeded to Wallace, Kans., soon after, and took charge of the station which had been established there by Mr. Dean in the grounds of the Union Pacific Railroad.

Between Ellsworth and Wallace, exchanges of arbitrary signals by telegraph for longitude were obtained on the nights of September 24, 25, 26, and 29, after which Messrs. Smith and Parsons exchanged stations, and similar exchanges were obtained on the nights of October 1, 3, 4, 5, and 6.

The latitude of the station at Wallace was determined by Mr. Smith, who observed for this purpose sixteen pairs of stars on six nights, making seventy-four observations in all.

From Ellsworth Mr. Parsons proceeded to Colorado Springs, and on the nights of October 9, 12, 13, 14, and 15 exchanged longitude signals with Mr. Smith at Ellsworth. After the observers had changed places, similar determinations were made on the nights of October 20, 21, 22, and 23. This closed the field-work of the season. With the exception of the tents and chronometers, which were returned to the office at Washington, the entire outfit of the parties was stored at Colorado Springs.

During the winter and early spring Mr. Smith was engaged on office duty in Washington, and in April received instructions to prepare for longitude work at stations in Colorado and New Mexico. Reference to this duty, in which Assistant Sinclair took part, will be made under the heading of the following section.

SECTION XVI.

NEVADA, UTAH, COLORADO, ARIZONA, AND NEW MEXICO. (SKETCHES Nos. 2, 14, 15, 16, and 17.)

Transcontinental triangulation near the thirty-ninth parallel carried to the eastward from stations in central Utah.—Arrangements for advancing towards the eastward the transcontinental triangulation in central Utah were made by Assistant William Eimbeck, in pursuance of instructions issued towards the end of June, 1885.

Mr. Eimbeck arrived at Salt Lake City on the 14th of July, and was occupied during the remainder of the month in organizing his party and in transferring it, with instruments, camp outfit, and pack animals, to Marysvale, at the base of Mount Tushar (formerly known as Mount Belknap), the station it was intended to occupy. This mountain rises some six thousand two hundred feet above Marysvale, and has an elevation above sea-level of about twelve thousand two hundred feet.

At the end of July an advance party had been engaged nearly a week in locating and opening a pack trail up Bullion Cañon to the very base of the peak proper. The month of August was occupied in completing pack trail to top of peak; in packing outfit, instruments, &c., to camp Tamarack and thence to the peak; in preparing the peak for the reception of the instruments, and in establishing camp and party at the peak, all of which was accomplished by the 20th of the month. Seven parties of heliotropers were also dispatched and posted.

The large theodolite was placed in position August 18, and observations begun the same day, but not much was accomplished by the end of the month, owing to unfavorable weather. During September, however, the conditions were favorable for the vigorous prosecution of the work, and by the 22d of that month the observations of horizontal directions, primary, secondary, and tertiary, had been brought to a successful conclusion. The remainder of the month was required to dismount instruments, strike tents, and transfer everything on the backs of pack animals to a lower camp.

The party left this lower camp September 29, and Mr. Eimbeck took up the work of connecting Lieutenant Wheeler's astronomical station at Gunnison, in the Sevier River Valley, Utah, with the primary triangulation. Mr. G. F. Bird served acceptably as an aid in the party.

Determinations of the longitudes of Santa Fé, N. Mex., and of Gunnison, Colo.—Magnetic observations at the same stations.—Under instructions issued in April, 1886, Assistants Edwin Smith and C. H. Sinclair proceeded to Colorado Springs, Colo., and, having organized their respective parties, took up the determination of the difference of longitude between Colorado Springs and Santa Fé, N. Mex. The station here was established by Mr. Sinclair in the grounds of Fort Marcy, and was identical with that of the United States Engineers, thus connecting the two surveys. Telegraphic longitude signals were exchanged on the nights of May 7, 8, 14, 17, and 18, when the observers changed stations, and a second set of exchanges was obtained on the nights of May 21, 27, 28, 31, and June 9.

At Santa Fé observations were made by Mr. Smith on three days for the magnetic declination, dip, and intensity.

From Santa Fé Mr. Smith proceeded to Gunnison, Colo., where he established a station in the grounds of the Court-House. With Mr. Sinclair at Colorado Springs, signals for longitude were

exchanged on the nights of June 17, 18, 23, and 26. Magnetic observations were made at Gunnison by Mr. Smith on three days, determining the declination, dip, and intensity.

After an exchange of stations on the part of the observers, a longitude determination was obtained June 30, and the work was continued after the close of the fiscal year.

During the month of May and the early part of June the weather was very unfavorable at Santa Fé, and during June it was unfavorable at Colorado Springs; on this account the progress of the work was less rapid than had been expected.

SPECIAL OPERATIONS.

Conference with the Inspector of Weights and Measures for the State of Rhode Island and with a Committee of the Legislature of that State in regard to a standard measure of length and the establishment of a meridian line.—In compliance with a request from Prof. John H. Appleton, Inspector of Weights and Measures for the State of Rhode Island, Mr. E. B. Lefavour, of the Weights and Measures Office, was directed to proceed to Providence, R. I., to confer with that officer respecting the construction of a mural standard of length and also with regard to the establishment of piers for fixing a meridian line.

At the conference, which was held August 25, Mr. Stephen A. Cooke, jr., was present on the part of the State legislature, and the Mayor of Providence and the City Engineer on the part of the municipal authorities.

After an examination of various localities, the Dexter Driving Park was selected for the site of the meridian piers, and, under certain conditions, a hall-way in the Court-House for the standard of length.

For this standard, the construction recommended as the best, was an iron bar of sufficient length resting upon a bench of stone, this bench to be supported by piers or brackets fastened to the walls of the building; the iron bar to rest directly upon brass rollers which are so arranged as to allow free access of air to the bar below as well as above. In cross-section the bar may be half an inch thick by one and one-half or two inches wide.

To insure permanence in molecular structure the bar may be heated to a red heat and allowed to cool slowly. Painting it with asphalt dissolved in turpentine will prevent it from rusting.

The defining marks are made on German-silver pins inserted into the bar at fifty and one hundred feet, and at lesser distances if needed.

With regard to the meridian piers, it was recommended that care should be taken to have them at least fifty feet away from any iron water-pipes, lamp-posts, or iron railing, and that all due precaution should be observed to obtain a firm foundation. If the frost line is at six feet, the foundation should begin at seven and a half feet below the surface. Beginning then with a square five feet on a side, a pyramidal pile of broken stone and cement is built up to the surface, where it is, say, twenty inches square. Above this is to be built a brick pier eighteen inches square, surmounted by a stone cap twelve inches thick. To the north or south of this pier, a meridian line having been laid out by means of a theodolite or transit instrument and observations of the sun or of the pole star, a similarly constructed pier is built which may be at a distance of sixty-eight and seventy-six one-hundredth meters, or two hundred and twenty-five feet seven and one tenth inches.

On the south pier, two arrangements may be made for centering, one by means of concentric rings, diagonals, and three lines 120° apart cut permanently into the slate; the other by having a brass plummet poised over the center by a weight so as to be freely raised or lowered.

The top of the north pier is provided with an upright sight, *i. e.*, a slit, one centimeter (thirty-nine hundredths of an inch) wide, and twenty centimeters (seven and nine-tenths inches) high, cut in a vertical brass plate; this opening may be made more distinct by a sheet of white paper behind it in day-time, or it may be illuminated by a light if used at night. Vertical black lines may be drawn on the brass plate above and below to mark the axis of the slit. The upright plate is secured to a horizontal plate of brass cemented and bolted down upon the stone pier.

At the distance suggested, an error in pointing of one centimeter would not involve an angular error greater than half a minute of arc. But it would be easy to point much closer, say to one-

fifth of a centimeter or about eight-hundredths of an inch. Hence the degree of accuracy would be ample for the purposes for which the meridian piers were established.

For many of the suggestions made, Mr. Lefavour acknowledges his indebtedness to Assistant Schott, who prepared a paper on the subject for the use of the City Engineer.

Suboffice at Philadelphia.—The charge of the suboffice at Philadelphia was continued with Assistant Spencer C. McCorkle. He has endeavored as heretofore to establish closer relations between the Survey and the people of the city, and to afford information in regard to its publications or work to all inquirers.

During the year requests for information were responded to from United States officials located in the city; from the Geological Survey of the State of New Jersey; from the Board of Port Wardens, the Survey Department and Water Department of Philadelphia, and from the American Philosophical Society; the Pennsylvania Historical Society; the Maritime Exchange; the Engineer's Club; the Franklin Institute, and the Mercantile Library.

Office facilities were furnished at various times during the year to the following-named officers of the Survey: Assistants Henry Mitchell, R. M. Bache, H. L. Marindin, C. M. Bache, and Mr. Charles Junken.

In addition to the charge of the suboffice, Assistant McCorkle, during July and August, 1885, had supervision of the topographical survey of the shores of the Delaware River above Bridesburg, executed by the city authorities. In January, February, and March, 1886, he observed the movement of ice in the river and bay, as referred to elsewhere in this report.

COAST AND GEODETIC SURVEY OFFICE.

Assistant B. A. Colonna, who was assigned to the charge of the office and topography July 24, 1885, succeeding Assistant C. O. Boutelle in that capacity, presents in his annual report (Appendix No. 4) a concise summary of office operations during the fiscal year. After a reference to the changes in the office *personnel* which occured at the time of his assignment as Assistant in charge, and to the trying ordeal to which the Survey was subjected by the course of events during the year, Mr. Colonna alludes to reforms accomplished in business methods in the office, some of which had been projected and in part carried out by his predecessors. To the chiefs of the office divisions he expresses his appreciation of their cordial support in the performance of the exacting and laborious duties which devolved upon him.

An increase of force in the Computing, Drawing, and Engraving Divisions of the office is urged as needed to meet the demands of the work.

Assistant C. A. Schott, in charge of the Computing Division, has directed the labors of the computers, reported the results of computations, answered calls for information, and submitted a number of reports of special value. He has determined in geographical position a geodetic line of nearly four hundred and five statute miles in length, forming part of the boundary between California and Nevada, and has in preparation a sixth edition of his paper on the Secular Variation of the Magnetic Declination in the United States and at some Foreign Stations. He has taken up also the computation, discussion, and preparation for the press of the records of the U. S. Arctic Expedition under Lieut. A. W. Greely, U. S. A.

Mr. W. T. Bright served as clerk to the Drawing Division till the close of his connection with the Survey, September 30, when Mr. T. J. O'Sullivan, draughtsman, was placed in charge of it. Soon after the death of Mr. O'Sullivan, which took place March 5, 1886, Assistant E. Hergesheimer was assigned to duty as its chief. Mr. Hergesheimer's exceptional skill as a topographer and draughtsman has been of great service in perfecting the re-organization of this division.

Assistant Herbert G. Ogden has continued in charge of the Engraving and Electrotyping Division, and has been active in his efforts to introduce every economy into the purchase of material and supplies, and to keep up the high standard of faithful and artistic delineation reached by the best topographical engravers. Mr. Ogden has given special attention to the selection of improved chart papers, and has succeeded in getting manufacturers interested in the production of papers showing a high average of good qualities. In the Electrotyping and Photographing branch of the work, Mr. D. C. Chapman, who succeeded Dr. Zumbrock, has introduced new and

simplified methods, reducing the waste of material and increasing the amount of copper deposited in a given time; he has been very successful also in making photographic reductions from original sheets, and, by an ingenious device of his own invention, in mounting them to scale.

Upon July 24, 1885, Mr. C. N. Saegmuller was relieved from the charge of the Instrument Division, and in August of that year Assistant Andrew Braid was assigned to its direction. In addition to the large amount of repairs, alterations, and preparation of instruments for field use which were attended to by the mechanicians, many improvements were made under Mr. Braid's direction in the system of work, the care of material, and in the keeping of the accounts and inventories of instruments and general property. The dividing engine was thoroughly overhauled and adjusted for making closer graduations than any before attempted in the office; the construction of a personal equation apparatus was advanced towards completion, and that of a machine for grinding spirit levels with greater accuracy and uniformity was begun. Mr. Braid was charged also with the details of the Office of Construction of Standard Weights and Measures, a duty to which he gave much study and to the performance of which he brought much skill. His reports of these duties form part of the report of the Assistant in charge of the office.

Mr. R. S. Avery, who had been connected with the Survey since 1853, and had been in charge of the Tidal Division since 1866, resigned September 30, 1885, and was succeeded by Mr. A. S. Christie. Under Mr. Christie's direction, and with the skillful aid of Mr. L. P. Shidy, for many years past attached to the division, the office work relating to tides was systematically laid out and vigorously prosecuted. Tide tables were computed in advance for the year 1887, and part of the proof read; these tables were much enlarged and improved for the ports on the Atlantic coast, and by means of plans devised for facilitating computations the labor of preparing the tide tables will be somewhat reduced, so that it is hoped to have the tables for 1888 ready in January 1887.

The Miscellaneous Division has continued under the charge of Mr. M. W. Wines, General Office Assistant. All of the business of the office with the Public Printer was conducted by him with promptness and good judgment; improvements were made in the administration of the chart-room and in its methods of account; he had also the care of the correspondence with sale agents for the charts and other publications of the Survey, and the supervision of the messengers and laborers in the office.

In November, 1885, Mr. Artemus Martin was appointed to the charge of the Archives and Library. It was hoped that he would be able to make a much-needed re-arrangement and cataloguing of the library and introduce improved methods of record for the volumes of observations and field-sheets, but owing to repeated attacks of illness this has not yet been accomplished.

A change in the Accounting Division of the office having taken place in July, 1885, by the retirement of Mr. W. B. Morgan, Disbursing Agent of the Survey, the duties of that position were assigned to Mr. George A. Bartlett, Disbursing Clerk of the Treasury Department. Mr. John W. Parsons was assigned to aid Mr. Bartlett as Chief Accountant. Mr. Parsons's thorough knowledge of the accounts of the Survey, and his tireless industry, made his services of special value to the work during a trying period in its history.

In the office of the Assistant in Charge Dr. W. B. French rendered service as executive and accounting clerk which is highly commended by his official chief.

In the office of the Superintendent, Assistant Andrew Braid continued on duty as executive officer and adviser until July 23, 1885, when the changes that then took place in the office organization led to his transfer to other duty, as stated above. It should have been mentioned in the last Annual Report that Mr. Braid was on duty in the office of the Superintendent, in the capacity just referred to, during the entire fiscal year ending June 30, 1885.

Mr. W. B. Chilton served as clerk in the office of the Superintendent, and Mr. C. D. Gedney during part of the year as stenographer.

CONCLUSION.

The preparation of this Report, with the editing for publication of the last Annual Report and appendices thereto, was intrusted to Assistant Edward Goodfellow. The report for the fiscal year

ending June 30, 1885, was ordered printed by Congress in July of the present year, and is now passing through the press. It is hoped that it will be issued early in 1887.

In transmitting this report to the Department, after more than a year of service as Superintendent of the Survey, with special opportunities for obtaining, even within that brief period, some personal knowledge of the value of the work accomplished, of its practical usefulness, of the increasing public demand for its results, of the demonstration of its high scientific accuracy, of the plausibility which slight acquaintance lends to the most fallacious criticism of its general methods, and of the certainty with which better knowledge of those methods is followed by increased respect for them, I desire to place upon record my sense of the earnest effort and steady devotion to duty of most of its trained field officers and office employés, and my conviction that the present organization of the work should in its general features remain essentially unchanged. That organization and its methods are not the complete result of a single creative act; they are the product of more than half a century of growth, and to their development, Hassler, Bache, Peirce, and Patterson eminent in scientific attainment and in administrative ability, devoted their highest efforts during more than the life-time of a single generation.

The merit of such an organization and of its methods is in no wise compromised by faults or vices in administration, and the remedy for such faults or vices is to be found for this Bureau, precisely as for any other Bureau or Department of the Government, not in disorganization, but in corrected administration. Since no institution has been or can be entirely exempt from occasional maladministration, the general adoption of disorganization as its remedy would long since have destroyed every executive Bureau and Department.

The criticisms recently urged against the organization, methods, and published results of the Survey are identical with those which were opposed to the original undertaking in 1807, and which were repeated in 1832, 1843, and 1849. In every instance it was shown that the criticisms were fallacious. In the attacks to which it has been thus subjected, the Survey was not only defended by the ablest scientific men of the time (such as Humboldt, Arago, Schumacher, Henry, Agassiz, &c.), and by the leading scientific bodies, commercial organizations, and educational institutions of the country, but the practical wisdom of the plan and methods, which were originally sanctioned by Jefferson and Gallatin in 1807, was vindicated by their resumption in 1836, after the confessed failure of the experiment of placing the work under naval control; by their formal and unanimous re-adoption in 1843 by a board consisting of three civilians, two Naval and four Army officers, and by the fact that no one of the naval officers who has had general charge of the hydrographic operations of the Survey has favored a change of such plan and methods.

Of the criticisms directed against these methods, the most frequent and plausible are the alleged subordination of hydrography to other operations of the Survey, and the undue extent and elaboration of its topography. Those criticisms are not only unfounded in fact, but they are amenable to the significant commentary that no complaint of the subordination of hydrography has been made by any one of the naval officers under whose direction the general hydrographic work of the Survey has been carried on; that no occasion was found to modify its hydrographic work by the ex-naval officer and experienced navigator who was Superintendent from 1874 to 1881, and that emphatic testimony to the immeasurable value of the detailed and extended topography executed by the Survey in conformity to its organic law, "for purposes either of commerce or of defense," has been borne by Generals W. F. Smith, H. G. Wright, M. C. Meigs, J. S. Negley, and others whose fields of operation during the late war enabled them to speak from actual experience.

The controversy from time to time renewed by the revival of the same fallacious but plausible criticisms is as old as the Survey itself. No study of that controversy would be complete which did not include the report in 1828 of Hon. Samuel L. Southard, Secretary of the Navy, in condemnation of the results of the work while under naval control, and the report made in 1851 by Hon. Thomas Corwin, Secretary of the Treasury, in answer to a resolution of the Senate relative to the transfer of the Coast Survey to the Navy Department.

Respectfully submitted.

F. M. THORN,
Superintendent.

Hon. DANIEL MANNING,
Secretary of the Treasury.

PART III.

APPENDICES.

APPENDIX No. 1.—1886.

DISTRIBUTION OF THE PARTIES OF THE COAST AND GEODETIC SURVEY UPON THE ATLANTIC, GULF OF MEXICO, AND PACIFIC COASTS, AND IN THE INTERIOR OF THE UNITED STATES DURING THE FISCAL YEAR ENDING JUNE 30, 1886.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION I.				
Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island, including coast and seaports, bays and rivers.	No. 1	Topography	A. W. Longfellow, assistant......	Topographical survey of the west bank of the Saint Croix River between Calais and Eastport, Me.
	2	Topography	Eugene Ellicott, assistant	Topographical surveys in the vicinity of Little River, Little Machias Bay, Cross Island Narrows, and Englishman's Bay, coast of Maine.
	3	Triangulation and topography.	C. H. Boyd, assistant; F. J. Mills.	Triangulation and topography of the coast of Maine in the vicinity of the towns of Machias, Machiasport, and Cutler. (See also No. 9 of this section.)
	4	Hydrography.....	Lieut. E. D. F. Heald, U. S. N., assistant; Ensigns J. M. Orchard, W. C. Canfield, J. E. Craven, W. J. Sears, and H. A. Field, U. S. N.	Hydrographic surveys of Pleasant River, Englishman's Bay, Little Kennebec River, and Machias River and Bay, coast of Maine.
	5	Special hydrographic examinations.	Lieut. G. H. Peters, U. S. N., assistant.	Hydrographic examinations on the coast of Maine for the Atlantic Coast Pilot. (See also Section III.)
	6	Hydrographic examinations.	Lieut. John M. Hawley, U. S. N., assistant.	Hydrographic examinations in Casco Passage and York Narrows, coast of Maine. (See also Sections II, VII, and VIII.)
	7	Tidal observations	J. G. Spaulding..................	Record of observations with self-registering tide-gauge continued at Pulpit Cove, North Haven Island, Penobscot Bay, Maine.
	8	Special hydrographic examinations.	Lieut. J. E. Pillsbury, U. S. N., assistant.	Special hydrographic examinations on the New England coast. (See also Sections II, III, and VI.)
	9	Topography	C. H. Boyd, assistant; C. H. Van Orden, subassistant.	Topographic resurvey of Monomoy Point, Massachusetts.
	10	Geodetic operations.	Prof. E. T. Quimby, acting assistant.	Continuation of geodetic operations in the State of New Hampshire.
	11	Geodetic operations.	Prof. V. G. Barbour, acting assistant.	Progress made in geodetic operations in the State of Vermont.
	12	Geodetic operations.	Henry L. Whiting, assistant; F. W. Perkins, assistant.	Determination of trigonometrical points in the Connecticut River Valley for the topographical survey of the State of Massachusetts.
	13	Geodetic operations.	Henry L. Whiting, assistant; C. H. Van Orden, subassistant.	Determination of the boundary lines of towns in the State of Massachusetts.
	14	Topography and hydrography.	Henry L. Whiting, assistant......	Topographic and hydrographic resurvey of Cotamy Beach, Martha's Vineyard, Massachusetts.
	15	Topography	W. H. Dennis, assistant...........	Topographic resurvey of Block Island.

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION II.				
Connecticut, New York, New Jersey, Pennsylvania, and Delaware, including coast, bays, and rivers.	No. 1	Hydrographic examination.	Lieut. J. E. Pillsbury, U. S. N., assistant.	Examination of a danger to navigation in Fisher's Island Sound. (See also Sections I, III, and VI.)
	2	Topography	W. I. Vinal, subassistant; W. B. Mapes, acting aid.	Topographical resurvey of the south shore of Long Island Sound from Roanoke Landing westward. (See also Section VII.)
	3	Hydrography.....	Lieut. F. H. Crosby, U. S. N., assistant; Ensigns J. S. Watters, G. W. Street, and C. E. Sweeting, U. S. N.	Additional soundings, inshore hydrography, Long Island Sound, from Hammonassett Point to SW. Ledge Light-house. (See also Section VIII.)
	4	Topography	W. H. Dennis, assistant; Lieut. G. Lange, Norwegian General Staff; E. A. Trescot.	Topographical resurvey of the north shore of Long Island Sound from Mulberry Point to Morgan's Point.
	5	Tidal observations	....	Tidal observations with an automatic tide-gauge at the Light-house on the New Haven Breakwater; also at Willet's Point, western end of Long Island Sound.
	6	Hydrography.....	Lieut. Sumner C. Paine, U. S. N., assistant; Ensigns T. D. Griffin and C. E. Sweeting, U. S. N.	Hydrographic resurvey of the north shore of Long Island Sound from Welch's Point to Sheffield Island.
	7	Triangulation.....	Gershom Bradford, assistant......	Extension of the triangulation for the resurvey of Long Island Sound from Eaton's Point on the north shore of Long Island to the eastward; also from the Hudson River to beyond Throg's Neck.
	8	Topography	Charles Hosmer, assistant; J. H. Turner, aid.	Continuation of the topographical resurvey of the north shore of Long Island Sound between Norwalk River and New Rochelle.
	9	Topography	W. C. Hodgkins, assistant........	Topographical resurvey of the south shore of Long Island Sound continued from Eaton's Neck to Cold Springs. (See also Section IV.)
	10	Hydrography.....	Lieut. D. D. V. Stuart, U. S. N., assistant; Ensigns W. G. Hannum and M. Johnston, U. S. N.	In-shore hydrography of Long Island Sound between Sheffield Island Light and Greenwich Point.
	11	Topography	E. Hergesheimer, assistant; J. H. Gray, aid.	Topographic resurvey of the East River from Red Hook towards Throg's Neck.
	12	Topography	C. T. Iardella, assistant	Topographic resurvey of the East River and of the western part of Long Island Sound continued.
	13	Hydrography.....	Lieut. John M. Hawley, U. S. N., assistant; Lieut. D. D. V. Stuart, U. S. N.; Ensigns F. H. Sherman, A. W. Dodd, and R. O. Bitler, U. S. N.	Hydrographic resurvey of the upper part of New York Bay and of the East River to Throg's Neck.
	14	Topography	D. B. Wainwright, assistant; James A. French, acting aid.	Topographic survey of the shore lines of the North River, New York; also of shore lines on Long Island and Staten Island. (See also Section IV.)
	15	Hydrography.....	Lieut. William G. Cutler, U. S. N., assistant; Ensigns E. E. Wright and A. G. Rogers, U. S. N.	Hydrographic resurvey of the North River and of Upper New York Bay, New York.
	16	Hydrography.....	Lieut. C. P. Perkins, U. S. N., assistant; Ensigns W. J. Sears, W. B. Fletcher, and C. S. Williams, U. S. N.	Special hydrography for the determination of tidal levels in the Hudson, Harlem, and East Rivers, and in Flushing, Little Neck, and Newark Bays.
	17	Magnetic observations.	James B. Baylor, subassistant....	Magnetic observations at stations in New York, New Jersey, Pennsylvania, and Delaware. (See also Sections V, VIII, and XIV.)
	18	Physical hydrography.	Henry Mitchell, assistant; Henry L. Marindin, assistant; Marcus Baker, assistant; Lieut. F. S. Carter, U. S. N., assistant.	Physical hydrography, New York Harbor resurvey. An epitome of results for "tidal flowage through New York Harbor. Progress of other investigations.

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION II—Continued.	No. 19	Topography	Joseph Hergesheimer, assistant; R. M. Bracken, acting aid.	Topographic resurvey of the shore-lines of Coney Island, Barren Island, and Rockaway Beach, New York Lower Bay. (See also Section VI.)
	20	Triangulation	R. E. Halter, assistant	Triangulation of Arthur Kill. (See also Section IX.)
	21	Topography	E. L. Taney, aid	Topographical resurvey of the shore-lines of Bergen Neck, lower part of Newark Bay, the Staten Island shore of Kill van Kull, and of Sandy Hook. (See also Section VIII.)
	22	Tidal observations		Tidal observations with automatic tide-gauges at Governor's Island and at Sandy Hook.
	23	Topography	R. M. Bache, assistant	Topographical resurvey of the shore-line of Staten Island from Stapleton southwestward.
	24	Hydrography	Lieut. G. C. Hanus, U. S. N., assistant; Ensigns C. S. Ripley, E. F. Leiper, F. R. Brainard, G. R. French, J. M. Elliott, and B. E. Thurston, U. S. N.	Hydrographic resurvey of New York Lower Bay and entrance. (See also Section V.)
	25	Determinations of gravity.	Charles S. Peirce, assistant	Gravity determinations and researches at stations between the Hudson and the Mississippi, and between the forty-first and forty-third parallels. (See also Sections III and XIV.)
	26	Geodetic operations.	Prof. Mansfield Merriman, acting assistant.	Continuation of the primary triangulation in the eastern part of the State of Pennsylvania.
	27	Reconnaissance	O. H. Tittmann, assistant; John E. McGrath, aid.	Reconnaissance for the extension of the triangulation in the eastern and northeastern parts of the State of Pennsylvania towards the boundary between Pennsylvania and New York. (See also Section VIII.)
	28	Reconnaissance	Prof. L. H. Barnard, acting assistant.	Reconnaissance for triangulation in the southern and western part of the State of Pennsylvania.
	29	Boundary survey	C. H. Sinclair, assistant	Completion of the survey of the parallel boundary between the States of Pennsylvania and West Virginia.
	30	Physical hydrography.	Henry L. Marindin, assistant	Delaware River above Petty's Island. Physical hydrography.
	31	Physical hydrography.	Spencer C. McCorkle, assistant	Formation and movement of ice in Delaware River and Bay.
	32	Special hydrography.	Charles Junken; Charles A. Junken.	Special survey of the Schuylkill River between Gray's Ferry and Rambo Point.
	33	Geodetic operations.	Prof. E. A. Bowser, acting assistant.	Continuation of the triangulation and reconnaissance of the southern part of the State of New Jersey.
	34	Topography	C. M. Bache, assistant	Continuation of the topographical resurvey of the coast of New Jersey.
	35	Topography	R. M. Bache, assistant	Completion of the topographic resurvey of the New Jersey shore of Delaware Bay.
	36	Physical hydrography.	Henry Mitchell, assistant	Changes in the Joe Flogger Shoal, Delaware Bay.
	37	Hydrography	Lieut. F. H. Crosby, U. S. N., assistant; Ensigns T. M. Brumby, A. L. Hall, J. H. Hetherington, F. W. Kellogg, J. S. Watters, and G. W. Street, U. S. N.	Completion of the hydrographic resurvey of lower Delaware Bay and entrance. (See also Section VIII.)
SECTION III. Maryland, District of Columbia, Virginia, and West Virginia, including bays, sea-ports, and rivers.	No. 1	Special survey	O. H. Tittmann, assistant; J. H. Turner, aid.	Tracing the Port-Warden lines of Baltimore Harbor. (See also Sections II and VIII.)
	2	Magnetic observation.	J. B. Baylor, subassistant	Magnetic observations at Fort McHenry (See also Sections II, V, VIII, and XIV.)

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION III—Continued.	No. 3	Magnetic observations.	Charles A. Schott, assistant	Magnetic observations at the station on Capitol Hill, Washington.
	4	Triangulation	C. H. Sinclair, assistant	Connection of the Washington Monument with the triangulation of the District of Columbia. (See also Sections II, XV, and XVI.)
	5	Topography	John W. Donn, assistant; J. A. Flemer, aid.	Continuation of the detailed topographical survey of the District of Columbia.
	6	Gravitation work.	Charles S. Peirce, assistant	Pendulum oscillations at the Smithsonian Institution, Washington. (See also Sections II and XIV.)
	7	Hydrographic examinations.	Lieut. G. H. Peters, U. S. N., assistant.	Hydrographic examinations for the Coast Pilot in Chesapeake Bay and its tributaries.
	8	Hydrographic examinations.	Lieut. J. E. Pillsbury, U. S. N., assistant.	Search for shoal reported off Assateague Light, Va. (See also Sections I to VI.)
	9	Geodesic leveling.	J. B. Weir, assistant; John Nelson, aid.	Examination of line of geodesic leveling between Richmond and Fredericksburg, Va. (See also Section VIII.)
	10	Boundary survey.	C. H. Sinclair, assistant	Completion of the survey of the boundary line near the 40th parallel between West Virginia and Pennsylvania. (See also Sections II, XV, and XVI.)
SECTION IV.				
North Carolina, including coast, sounds, seaports, and rivers.	No. 1	Special hydrography.	Lieut. Francis Winslow, U. S. N., assistant; Lieut. Burns T. Walling, U. S. N.; Ensign J. C. Drake, U. S. N.	Special hydrography for the State of North Carolina. Surveys of oyster beds.
	2	Triangulation and beach measurement.	W. C. Hodgkins, subassistant	Connection of the triangulations of 1853 and 1873 on the coast of North Carolina. Beach measurement near the boundary line between North and South Carolina. (See also Section II.)
	3	Triangulation	D. B. Wainwright, assistant	Junction of the triangulation at the mouth of Cape Fear River with that at Little River Inlet. (See also Section II.)
	4	Hydrography	Lieut. J. E. Pillsbury, U. S. N., assistant; Ensigns T. D. Griffin, R. M. Hughes, A. G. Rogers, J. H. Hetherington, and F. R. Brainard, U. S. N.	Hydrographic examinations in the vicinity of Frying-Pan Shoals. (See also Sections I, II, III, and VI.)
SECTION V.				
South Carolina and Georgia, including coast, sea-water channels, sounds, harbors and rivers.	No. 1	Magnetic observations.	J. B. Baylor, subassistant	Magnetic observations at Aiken and at Charleston, S. C., and at Savannah, Ga. (See also Sections II, III, VIII, and XIV.)
	2	Hydrography	Lieut. G. C. Hanus, U. S. N., assistant; Ensigns C. S. Ripley, G. R. French, and E. F. Leiper, U. S. N.	Hydrographic examinations in North and South Santee Rivers, Bull's Bay, Price's, Caper's, and Dewees Inlets, and Charleston Harbor, S. C. (See also Section II.)
SECTION VI.				
Peninsula of Florida, from Saint Mary's River, on the east coast, to and including the Anclote Keys, on the west coast, with the coast approaches, reefs, keys, seaports, and rivers.	No. 1	Physical hydrography.	Lieut. J. E. Pillsbury, U. S. N., assistant; Ensigns T. D. Griffin, R. M. Hughes, A. C. Rogers, J. H. Hetherington, and F. R. Brainard, U. S. N.	Physical hydrography. Observations of currents in the Gulf Stream. Deep-sea soundings from Florida Reefs to Salt Key Bank, and thence to Bahama Banks. Examination of a seventeen feet spot in Key West Harbor. (See also Sections I, II, III, and IV.)
	2	Beach measurement, triangulation, and observations for latitude and azimuth.	Joseph Hergesheimer, assistant; E. D. Preston, subassistant; J. H. Gray, aid.	Beach measurement and triangulation, with observations for latitude and azimuth on the west coast of Florida between Cape Sable and Cape Romano. (See also Section II.)

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION VII.				
Peninsula of Florida, west coast, from Anclote Keys to Perdido Bay, including coast approaches, bays, and rivers.	No. 1	Topography	W. I. Vinal, subassistant; W. B. Mapes, acting aid.	Topographical survey of the west coast of Florida north of Anclote Keys. (See also Section II.)
	2	Hydrography	Lieut. J. M. Hawley, U. S. N., assistant; Ensigns E. E. Wright, A. W. Dodd, John E. Craven, R. O. Bitler, and Harry A. Field, U. S. N.	Hydrographic survey off the west coast of Florida to the north of the Anclote Keys. (See also Sections I and VIII.)
SECTION VIII.				
Alabama, Mississippi, Louisiana, and Arkansas, including Gulf coasts, ports, and rivers.	No. 1	Triangulation	O. H. Tittmann, assistant; J. E. McGrath and J. Henry Turner, aids.	Progress made in the extension of the primary triangulation in Northern Alabama towards the Gulf of Mexico. (See also Sections II and III.)
	2	Geodesic leveling	John B. Weir, assistant; John Nelson, aid.	Line of geodesic levels run from Mobile to New Orleans, and from Meridian, Miss., to Quitman, Miss. (See also Section III.)
	3	Hydrography	Lieut. John M. Hawley, U. S. N., assistant; Ensigns A. W. Dodd, John E. Craven, R. O. Bitler, and Harry Field, U. S. N.	Hydrographic examination in the vicinity of the Chandeleur Islands, and hydrographic resurvey of Horn Island Pass. (See also Sections I and VII.)
	4	Triangulation, topography, and magnetic observations.	F. W. Perkins, assistant; E. L. Taney, acting assistant; J. B. Baylor, subassistant; G. F. Bird, aid.	Triangulation, topographical survey, and magnetic observations on the coast of Louisiana between Barataria Bay and the Mermentou Rivers. (See also Sections I and II.)
	5	Hydrography	Lieut. F. H. Crosby, U. S. N., assistant; Lieut. F. S. Carter, U. S. N.; Ensigns J. S. Watters, G. W. Street, and C. E. Sweeting, U. S. N.	Hydrographic surveys on the coast of Louisiana from Southwest Pass westward, in Barataria Bay, and in Coté Blanche Bay. (See also Section II.)
SECTION IX.				
Texas and Indian Territory, including Gulf coast, bays, and rivers.	No. 1	Base measurement and triangulation.	R. E. Halter, assistant	Measurement of a base-line and connection of this line with the triangulation near Brownsville, Tex. (See also Section II.)
SECTION X.				
California, including the coast, bays, harbors and rivers.	No. 1	Triangulation and topography.	A. F. Rodgers, assistant; Isaac Winston, aid.	Triangulation and topography of the coast of California between Newport Bay and San Mateo.
	2	Magnetic observations.	Carlisle Terry, jr., subassistant; R. A. Marr, subassistant.	Record of magnetic observations continued with self-registering apparatus at Los Angeles, Cal.
	3	Reconnaissance for site of base-line.	J. S. Lawson, assistant; E. F. Dickins, assistant.	Reconnaissance for the site of a primary base-line in Los Angeles County, California.
	4	Triangulation and topography.	Stehman Forney, assistant	Continuation of the triangulation and topography of the south coast of California between Estero Point and Point Sur.
	5	Triangulation	James S. Lawson, assistant; P. A. Welker, aid.	Occupation of stations in continuation of the primary triangulation of the coast of California north of Point Concepcion.
	6	Triangulation and astronomical and magnetic work.	George Davidson, assistant; E. F. Dickins, assistant; Fremont Morse, aid.	Connection of the triangulation depending upon the Pulgas Base with that depending upon the Yolo Base. Occupation of stations in continuation of the primary triangulation near the southern coast of California. (See also Section XI.)
	7	Shore-line surveys.	A. F. Rodgers, assistant; Isaac Winston, aid.	Shore line resurvey of Carquines Straits and San Pablo Bay. Resurvey of the shore-line topography of the Golden Gate and approaches.
	8	Tidal observations	Emmet Gray, observer	Tidal record continued at self-registering tide-gauge station at Saucelito, Bay of San Francisco.

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION X—Continued.	No. 9	Astronomical observations.	George Davidson, assistant; James S. Lawson, assistant; Fremont Morse, P. A. Welker, and C. B. Hill, aids.	Observations at San Francisco of the eclipse of the sun, March 5, 1886.
	10	Hydrography	Lieut. E. D. Taussig, U. S. N., assistant; Lieuts. David Peacock and C. F. Pond, U. S. N.; Ensigns Simon Cook, W. L. Burdick, J. A. Bell, F. A. McNutt, J. H. Shipley, and C. W. Jungen, U. S. N.	Hydrographic survey of the coast of California off Cape Mendocino, and to the southward.
SECTION XI.				
Oregon and Washington Territory, including coast, interior bays, ports, and rivers.	No. 1	Triangulation, topography, and hydrography.	Louis A. Sengteller, assistant	Completion of the connection of the Koos Bay and Umpquah River triangulations. Progress of the topographic and hydrographic survey of the Umpquah River.
	2	Hydrography	Lieut. Commander A. S. Snow, U. S. N., assistant; Lieut. G. Blocklinger, U. S. N.; Ensigns F. M. Bostwick, W. P. White, J. H. Shipley, and C. W. Jungen, U. S. N.	Hydrographic surveys in Tillamook Bay, off the coast in that vicinity, and in Columbia River. (See also Section XII.)
	3	Hydrography	Cleveland Rockwell, assistant	Continuation of hydrographic work in the Columbia and Willamette Rivers.
	4	Astronomical and magnetic observations.	George Davidson, assistant; Cleveland Rockwell, assistant.	Observations for latitude and azimuth, and for magnetic declination and horizontal intensity at stations in Oregon and Washington Territory. (See also Section X.)
	5	Inspection and reconnaissance.	George Davidson, assistant	Inspection of field-work on the coasts of Oregon and of Washington Territory. Reconnaissance for Coast Pilot. (See also Section X.)
	6	Triangulation and topography.	J. F. Pratt, assistant	Triangulation and topography of Possession Sound completed. Completion of the topographical survey of Snohomish River. Telegraphic determination of the longitude of Tatoosh Island Light.
	7	Hydrography	Lieut. C. F. Forse, U. S. N., assistant; Ensign J. N. Jordan, U. S. N.	Hydrographic surveys in Admiralty Inlet and in Puget Sound.
	8	Triangulation and topography; determination of longitude.	J. J. Gilbert, assistant	Triangulation and topography of Rosario Strait and Burrows Bay. Longitude signals exchanged with Tatoosh Island Station.
SECTION XII.				
Alaska, including the coast and the Aleutian Islands.	No. 1	Hydrographic surveys, with astronomical and topographic work.	Lieut. Richardson Clover, U. S. N., assistant; Lieut. Commander A. S. Snow, U. S. N., assistant; Lieut. J. H. Helm, U. S. N.; R. A. Marr, subassistant, C. & G. S.; Ensigns Walter McLean, C. C. Marsh, A. P. Niblack, D. P. Menefee, and T. G. Dewey, U. S. N.	Hydrographic surveys, determinations of geographical positions, triangulation and topography in Southeastern Alaska.
	2	Tidal observations.	F. Sargent, tide-observer	Series of tidal observations with self registering tide-gauge continued at Saint Paul, Kadiak Island, Alaska.
SECTION XIII.				
Kentucky and Tennessee	No. 1	Primary triangulation and reconnaissance.	A. T. Mosman, assistant	Extension westward of the primary triangulation and reconnaissance near the 39th parallel in Ohio and Kentucky. (See also Section XIV.)
	2	Geodetic operations.	Prof. A. H. Buchanan, acting assistant.	Occupation of stations in continuation of the triangulation of the State of Tennessee.

APPENDIX No. 1—Continued.

Sections.	Parties.	Operations.	Persons conducting operations.	Localities of work.
SECTION XIV.				
Ohio, Indiana, Illinois, Michigan and Wisconsin.	No. 1	Primary triangulation and reconnaissance.	A. T. Mosman, assistant; W. B. Fairfield, extra observer.	Extension westward of the primary triangulation and reconnaissance near the 39th parallel in Ohio and Kentucky. (See also Section XIII.)
	2	Geodetic operations.	Prof. R. S. Devol, acting assistant.	Occupation of stations for continuing the triangulation of the State of Ohio.
	3	Triangulation.	George A. Fairfield, assistant; John B. Weir, assistant; F. P. Bacon, recorder.	Extension to the eastward in the State of Indiana of the transcontinental triangulation near the 39th parallel.
	4	Geodetic operations.	Prof. J. L. Campbell, acting assistant.	Continuation of triangulation and reconnaissance in the State of Indiana.
	5	Determinations of gravity.	Charles S. Peirce, assistant.	Determinations of gravity at Ann Arbor, Mich., and at Madison, Wis. (See also Sections II and III.)
	6	Magnetic observations.	James B. Baylor, subassistant ...	Observations for magnetic declination, dip, and intensity at a station in Detroit, Mich. (See also Sections II, III, V, and VIII.)
	7	Geodetic operations.	Prof. J. E. Davies, acting assistant.	Continuation of the triangulation of the State of Wisconsin.
	8	Latitude observations.	F. H. Parsons, subassistant	Observations for latitude at Madison, Wis. (See also Section XV.)
SECTION XV.				
Missouri, Kansas, Iowa, Nebraska, Minnesota, and Dakota.	No. 1	Triangulation.....	F. D. Granger, assistant; E. D. Preston, subassistant.	Extension westward of the primary triangulation in Missouri and Kansas, near the 39th parallel.
	2	Determinations of latitude and longitude.	George W. Dean, assistant; Edwin Smith, assistant; C. H. Sinclair, assistant; F. H. Parsons, subassistant; E. D. Preston, subassistant.	Differences of longitude by telegraphic signals between Kansas City, Mo., Ellsworth and Wallace, Kans., and Colorado Springs, Colo. Latitude observations at Ellsworth and Wallace. (See also Section XVI.)
SECTION XVI.				
Nevada, Utah, Colorado, Arizona, and New Mexico.	No. 1	Triangulation.....	William Eimbeck, assistant.......	Transcontinental triangulation near the 39th parallel carried to the eastward from stations in Central Utah.
	2	Longitude determinations and magnetic observations.	Edwin Smith, assistant; C. H. Sinclair, assistant.	Determinations of the longitudes of Santa Fé, N. Mex., and Gunnison, Colo. Magnetic observations at the same stations. (See also Section XV.)
SPECIAL OPERATIONS.		Conference with the Inspector of Weights and Measures for the State of Rhode Island and with a committee of the Legislature of that State in regard to a standard length measure and a meridian line.	E. B. Lefavour	
		Charge of the suboffice at Philadelphia.	S. C. McCorkle, assistant	

APPENDIX No. 2.—1886.

STATISTICS OF FIELD AND OFFICE WORK OF THE COAST AND GEODETIC SURVEY FOR THE YEAR ENDING JUNE 30, 1886.

	Total to June 30, 1885.	Total during fiscal year.	Total to June 30, 1886
RECONNAISSANCE.			
Area in square statute miles	377, 960	900	378, 860
Parties, number of	....	4	....
BASE LINES.			
Primary, number of	14	0	14
Primary, length of, in statute miles	90	0	90
Subordinate, number of	130	1	131
Subordinate and beach measures, length of	476	29	505
TRIANGULATION.			
Area in square statute miles	199, 864	8, 007	207, 871
Stations occupied for horizontal measures, number of	11, 080	248	11, 328
Geographical positions determined, number of	21, 105	574	21, 679
Stations occupied for vertical measures, number of	762	30	792
Elevations determined trigonometrically, number of	1, 915	82	1, 997
Heights of bench-marks by spirit-leveling, number of	3, 014	267	3, 281
Lines of spirit-leveling, length of, in statute miles	3, 330	166	3, 496
Triangulation and leveling parties, number of	....	32	....
ASTRONOMICAL WORK.			
Azimuth stations, number of	190	9	199
Latitude stations, number of	318	10	328
Longitude stations, telegraphic, number of	127	5	132
Longitude stations, chronometric or lunar, number of	110	0	110
Astronomical parties, number of	....	8	....
MAGNETIC WORK.			
Stations occupied, number of	693	16	709
Permanent magnetic stations, number of	....	2	....
Magnetic parties, number of	....	8	....
TOPOGRAPHY.			
Area surveyed, in square statute miles	30, 281	266	30, 547
Length of general coast, in statute miles	6, 742	100	6, 842
Length of shore-line, in statute miles, including rivers, creeks, and ponds	86, 505	1, 645	88, 150
Length of roads, in statute miles	44, 252	546	44, 798
Topographical parties, number of	....	27	....
HYDROGRAPHY.			
Parties, number of	....	17	....
Number of miles (geographical) run while sounding	378, 225	14, 932	393, 157
Area sounded, in square geographical miles	99, 580	14, 261	113, 841
Miles run, additional of outside or deep-sea soundings	75, 256	80	75, 336
Number of soundings	17, 007, 328	567, 968	17, 575, 296
Deep-sea soundings	13, 090	20	13, 110
Deep-sea temperature observations	12, 010	910	12, 920
Current stations, number of	....	47	....
Deep-sea current stations, number of	....	26	....
Deep-sea subcurrent observations, number of	....	1, 557	....
Deep-sea surface current observations, number of	....	1, 807	....
Specimens of bottom, number of	12, 628	216	12, 844

APPENDIX No. 2—Continued.

	Total to June 30, 1885.	Total during fiscal year.	Total to June 30, 1886.
HYDROGRAPHY—continued.			
Automatic tide-gauges established	85	0	85
Automatic tide-gauges discontinued	79	3	82
Parties doing tidal work exclusively	....	4	....
Parties doing tidal in connection with hydrographic work	....	15	....
Staff and box gauges established	1,644	67	1,711
Staff and box gauges discontinued	1,639	67	1,706
RECORDS.			
Triangulation, originals, number of volumes	4,582	265	4,847
Astronomical observations, originals, number of volumes	1,797	34	1,831
Magnetic observations, originals, number of volumes	627	38	665
Duplicates of above, number of volumes	4,917	294	5,211
Computations, number of volumes	3,975	190	4,165
Hydrographic soundings and angles, originals, number of volumes	9,322	464	9,786
Hydrographic soundings and angles, duplicates, number of volumes	2,175	300	2,475
Tidal and current observations, originals, number of volumes	3,686	169	3,855
Tidal and current observations, duplicates, number of volumes	2,402	90	2,492
Aggregate years of record from automatic tide-gauges	251	3	254
Tidal stations for which reductions have been made	965	7	972
Aggregate years of record reduced	208	3	211
MAPS AND CHARTS.			
Topographic maps, originals	1,678	75	1,753
Hydrographic charts, originals	1,817	65	1,882
Reductions from original sheets	962	(*)	(*)
Total number of manuscript maps and charts	2,725	(*)	(*)
ENGRAVING AND PRINTING.			
Engraved plates of finished charts, number of, printed from, for circulation	285	6	291
Engraved charts withdrawn from circulation	134	7	141
Finished charts published, total number of	419	6	425
Engraved plates of preliminary charts, sketches, and diagrams for the Coast and Geodetic Survey reports, number of	651	3	654
Electrotype plates made	1,824	42	1,866
Charts published by photolithography	....	14	....
Charts published by photolithography withdrawn from circulation	....	6	....
Engraved plates of Coast Pilot charts	80	0	80
Engraved plates of Coast Pilot views	89	0	89
Printed sheets of maps and charts distributed	564,295	30,521	594,816
Printed sheets of maps and charts deposited with sale agents	243,515	19,924	263,439

* A re-registration of these maps is being made as rapidly as practicable, but cannot be made ready for publication in time for insertion in this report.

Appendix No. 3.—1886.

INFORMATION FURNISHED TO DEPARTMENTS OF THE GOVERNMENT IN REPLY TO REQUESTS, AND TO INDIVIDUALS UPON APPLICATION,* DURING THE FISCAL YEAR ENDING JUNE 30, 1886.

Date.		Name.	Data furnished.
1885.			
July	1	Powell, J. W., Director U. S. Geological Survey	Descriptions of nine triangulation stations in Alabama and of three in Georgia.
	2	Bogart, J. P., Engineer of the Connecticut Shellfishery Commission.	Geographical positions of Milford and Milford Spire, distances and azimuths.
	2	Baird, Prof. S. F., U. S. Commissioner of Fish and Fisheries.	Physical surveys of Gulf Stream.
	3	Powell, J. W., Director U. S. Geological Survey	Geographical positions and descriptions of eighteen stations in Missouri.
	7	Hering, R., Engineer Philadelphia Water Department	Geographical positions of three stations.
	7	Bogart, J. P., Engineer Connecticut Shellfishery Commission.	Geographical positions and descriptions of two stations.
	7	Gray, Samuel M., City Engineer, Providence, R. I	Letters relating to tides, 1881 and 1882, at Providence, R. I.
	10	Saxton, Albert, Philadelphia, Pa	Weights and Measures, report for 1857, and papers relating to American and metric standards of length.
	17	The Collins Manufacturing Company, Collinsville, Conn	Two pamphlets on results of magnetic discussions.
	18	The Commissioner of the General Land Office	Computed positions in the geodetic line between the Colorado River and Lake Tahoe, part of the boundary of Nevada and California.
	20	President of Mobile and Ohio Railroad	Copy of survey of dredged channel, Mobile Bay.
	23	Tucker, W. R	Tracing showing results of a survey of a portion of the Schuylkill River, near Gray's Ferry.
	24	The Director of the Mint	A set of coin weights for the Philadelphia mint, and a set of standard grain weights from 1,000 grains to 0.01 grain, with their determined corrections.
	25	French, M., County Surveyor of Halifax County, Meadville, Va.	Table of secular variation of magnetic declination between 1730 and 1885 for Southern Virginia, and information as to distribution of magnetism in that region.
	28	Shedd, J. Herbert, C. E	Tracing of Little Narragansett Bay, Long Island Sound.
	29	Tripp, O. H., C. E., Rockland, Me	Description of tidal bench-mark, Rockland, Me.
	29	Bartlett, J. R., Commander U. S. N., Hydrographer, Bureau of Navigation.	Bearing of a line opposite New York in 1858 from recorded bearing of the same line in 1764.
	29	Troemner, Henry, Philadelphia, Pa	Verification and adjustment of two complete sets of weights and measures for Territory of Wyoming.
Aug.	3	Bogart, J. P., Engineer Connecticut Shellfishery Commission.	Three tracings of part of shore of Little Narragansett Bay, Long Island Sound.
	5	Goodwin, J. M., Sharpsville, Pa	Tides and tidal currents around Fortress Monroe, Va.
	5	Siegfried, R., Konigsburg, Prussia	Values of kilogram, troy and avoirdupois ounces, and value of United States gold coin weights in grains, and value of United States standard gallon and bushel. Value of meter in inches.
	6	Owen, W. O., Deputy County Surveyor, Laramie, Wyo	Length of a degree of longitude in latitude 41° and in latitude 43½°, and length of meridional arc intercepted by these parallels.
	10	Goodwin, J. M., Sharpsville, Pa	Tides at Fortress Monroe, Va., in 1862.
	12	Appleton, Prof. J. H., State Inspector of Weights and Measures, Providence, R. I.	Information concerning the construction of a mural standard and fixing of a meridian line.
	12	Smedley, Samuel L., Chief Engineer and City Surveyor, Philadelphia, Pa.	Twenty-seven geodetic positions in Philadelphia, Pa.

* Tracings from topographic or hydrographic sheets, transcripts of unpublished results of the work, and other data, when supplied for private use, are furnished upon payment of the cost of preparation in the office.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1885.			
Aug.	12	Powell, J. W., Director U. S. Geological Survey	One hundred and forty-six geographical positions, with geodetic data of the trigonometrical survey of Massachusetts, by Borden 1832-'38, as recomputed and adjusted to standard data at the Coast and Geodetic Survey Office.
	14	Wheeler, Capt. G. M., U. S. Engineers	Information respecting condition of a proposed map of the United States and the state of forwardness of the measure of an arc of the thirty-ninth parallel.
	14	Rickoff, A. J., Yonkers, N. Y	Weights and Measures Report of 1857 and papers relating to American and metric standards of length.
	14	Becker Bros., New York City	Results of verification of a kilogram and a hectogram sent for examination.
	15	Department of Surveys, city of Philadelphia	Supplementary triangulation, city of Philadelphia.
	17	Swain, E. A	Tracing of topography, west shore Hudson River, Grassy Point and vicinity.
	19	Nicholson, W. L., Topographer, Post-Office Department	Geographical positions in the States of Kentucky and Tennessee and near their boundaries.
	20	Austin, E. P., Salt Lake City, Utah	Advance proofs Tide Tables for Boston Harbor, 1886.
	31	Appleton, Prof. J. H., State Inspector of Weights and Measures, Providence, R. I.	Additional information concerning the construction of a mural standard and the fixing of a meridian line.
	31	Tate, George W., Mebanesville, N. C	Graduated and verified 33-feet steel tape.
Sept.	2	Branner, Prof. J. C., Indiana University, Bloomington, Ind.	Copy of reconnaissance of triangulation traversing the State of Indiana from east to west.
	8	Hubbard, Hon. L. F., Governor of Minnesota	Directions as to mode of obtaining duplicate set of standard balances to replace those destroyed by fire at Saint Paul in 1881.
	9	Field, J. W., Chincoteague, Accomac County, Va	Magnetic declination in Chincoteague at present and its annual change.
	10	Browne, J. Loyalist, Bowdoinham, Me	Copy of bench-marks at Abagadasset, Me.
	11	Williams, W., Surveyor, Hackensack, N. J	Change of magnetic declination at New York between 1820 and 1825.
	12	Smedley, Samuel L., Chief Engineer and Surveyor, Philadelphia, Pa.	Geographical positions of trigonometrical stations on the Delaware River, between Philadelphia and Rancocus.
	14	McElroy, Samuel, C. E., No. 50 Johnson street, Brooklyn, N. Y.	About tides in Huntington and Smithtown Bays, Long Island Sound.
	15	Cook, Prof. George H., State Geologist of New Jersey, New Brunswick, N. J.	Bench-marks at Absecon Light-house and Cape May.
	15	Bogart, J. P	Tracing of Clinton Harbor, Connecticut.
	17	Jannieson, A	Tracing between Alexandria and Mount Vernon.
	18	Walker, William, Acting Commissioner of the General Land Office.	New edition of article on the magnetic declination, with new tables and two maps.
	18	Pow, Arthur, Chief Engineer Macon and Dublin Railroad Company.	Geographical positions of Savannah and Macon, Ga.
	19	Bradford, Lawrence, Engineer	Information respecting two trigonometrical stations on Green Island, Boston Harbor.
	21	Symons, Capt. T. W., U. S. Engineers, Washington Aqueduct.	Height of bench-marks at the Aqueduct bridge, Georgetown, and the Capitol, Senate wing, above the mean level of the Atlantic.
	23	Siegfried, R., Konigsburg, Prussia	Equivalents of metric weights and measures, and value of the mile and its subdivisions.
	24	Mississippi River Commission	Hydrography of Mississippi River, Donaldsonville to Head of Passes.
	29	Talcott, G. R., Superintendent of the Charlotte, Columbia and Augusta Railroad, Columbia, S. C.	Information as to where to obtain a suitable set of standard weights.
	30	Field, J. W., Chincoteague, Accomac County, Virginia	Present bearing of a line originally run in 1840 on Assateague Island.
Oct.	3	Roote, C. B., Barre, Mass	Height of Monadnock Mountain, New Hampshire.
	7	Thompson & Slater	Steamship distances from Tampa, Fla., to Key West, and from Key West to Havana.
	8	Roberts, Lewis H., Clinton, Iowa	Advice for determination of the longitude of Clinton.
	8	Hackenberg, P. L., & Son, Milton, Pa	Report of Weights and Measures of 1857, and papers relating to metric standards.
	9	Bogart, J. P	Tracing of Clinton and vicinity, between Millstone Point and Hatchet Point, Connecticut.
	13	Botsford, F	Tracing of Hatchet, Black, and Millstone Points, Connecticut.
	14	Bogart, J. P	Projection $\frac{1}{10000}$ between Watch Hill and Noank.
	14	Hering, R., Engineer, Philadelphia Water Department	Geographical positions vicinity of Allentown, Easton, and Trenton.
	17	Haswell, C. H., Engineer and City Surveyor, New York	Magnetic declination at Riker's Island and annual change.
	17	Howe, W. B. W., jr., Chief Engineer Savannah, Florida and Western Ralway Company, Savannah, Ga.	Range of tides in Tampa Bay, Florida, with description of tidal bench-mark at Tampa, and of tide-staff at Gadsen's Point, Florida

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1885.			
Oct.	20	Osborne, E. A., Middletown, N. J	Magnetic declination, east coast of Florida, between latitudes 26° and 27°.
	22	Ewell, M. D., Chicago, Ill	Value of two glass scales, 1 centimeter and $\frac{1}{25}$ inch, respectively, determined for him by this bureau.
	27	......do	Description of apparatus for making accurate determinations of length (Blair comparator and Rutherfurd micrometer).
	28	Clarke, H. W., Engineer, New York and Pennsylvania Boundary, Syracuse, N. Y.	Geodetic data of line Howlett to Clyde, N. Y.
	28	Swan, Samuel A	Tracing of the country lying between Saint Mary's and Fernandina, Fla.
	29	Stockslager, S. M., Assistant Commissioner General Land Office.	Positions of astronomical stations in Arkansas and Missouri.
	30	Ramel, A., Observatory of Washington University, Saint Louis.	Geographical position of station "Hoile," Illinois.
	30	Baird, Prof. S. F	Tracing of Naushon Island.
Nov.	2	Brandis, F. E., New York	Length of a steel tape tested for him by this Bureau.
	3	Perkins, James P., County Surveyor, Myers County	Amount and change of magnetic declination during the last nine years and present bearing of two old lines.
	3	Taylor, C. E., Philadelphia	Four pamphlets on magnetic results bearing on the declination of the magnetic needle.
	4	Comstock, G. C., Professor of Mathematics Ohio State University, Columbus.	Geographical position of astronomical station at Columbus.
	5	Howe, W. B. W., jr., Civil Engineer Savannah, Florida and Western Railway Company, Savannah, Ga.	Mean half-tide level above mean low water at Savannah, Ga.
	6	Troemner, Henry, Philadelphia, Pa	Determinations of values of a set of measures made by him for Territory of Dakota, and verified and adjusted by this Bureau.
	10	Lee, General S. D., President Agricultural and Mechanical College, Mississippi.	Information concerning the procuring of a set of small standard weights for the college.
	10	Webb, Arthur A., City Superintendent Schools Fort Madison, Iowa.	Mean rise and fall of tide at fifteen stations on Chesapeake Bay and its tributaries.
	10	Abbot, General H. L., U. S. A	Tracing of Hell Gate, New York.
	12	Abbot, H. L., Brevet Brigadier-General U. S. A., Willet's Point, New York.	Distances and azimuths of points of observation of the earth's tremor due to the explosion at Flood Rock, Hell Gate.
	12	Lydell, G. A., Engineer Richmond and Danville Railroad	Geographical positions of prominent places in the United States east of longitude 94°.
	13	Lovick, H. J., County Surveyor, New Berne, N. C	Magnetic declination at Beaufort, N. C., in 1880.
	13	Botsford, F	Tracing of Hatchet, Black, and Millstone Points, Connecticut.
	14	Baker, Prof. I. O., Illinois University, Champaign, Ill	Coefficient of expansion of iron and steel and value of a steel tape tested for him by this Bureau.
	14	Fairbanks, E. T., & Co., Saint Johnsbury, Vt	Information concerning the variability of hollow standards.
	17	Peirce, Prof. C. S., U. S. Coast and Geodetic Survey	Length of yard pendulum No. 3 and its coefficient of expansion, determined by Weights and Measures Bureau.
	18	Powell, J. W., Director U. S. Geological Survey	Position and reference directions, station Peaked Mountain, Virginia.
	20	Crowell, H. S	Tracing of north shore of Buzzard's Bay, from Wareham River to New Bedford.
	20	Chubb, S	Tracing of "Watch Hill Reef."
	21	Balcomb, S. F., Assistant Engineer Illinois Central Railroad, Champaign, Ill.	Length of a standard tape tested for him by this Bureau.
	21	Seigfried, R., Königsburg, Prussia	Determination of values of the meter and kilogram in inches and grains for commercial and for scientific purposes.
	24	Fairbanks, E. & T., & Co., Saint Johnsbury, Vt	Information concerning the requirements and quality of standard weights to which it is desired to have our official stamps affixed.
	24	Jackson, Sheldon	Corrected map of Alaska.
	24	......do	Tracing of map of Eastern Alaska and sketch map of Alaska.
	25	Bushe, E. L	Tracing in the vicinity of New Rochelle.
	28	Stanton, Major, of Engineers	Magnetic declination at Cape Cod in 1796, 1826, 1837, and 1857.
	28	Montheith, J., New York	Height of Mitchell's High Peak and Clingman's Peak, North Carolina.
	28	Dull, J. J. & A. J., Harrisburg, Pa	Annual change in the magnetic declination in McMullen County, Texas, during the past ten years.
Dec.	3	Magee, Dr. Irving, Rondout, N. Y	Geodetic data for three triangulation points on the Hudson River, near Rondout.
	4	Ashburner, Prof. C. A., Geological Survey of Pennsylvania.	Tracing showing triangulation and reconnaissance in Pennsylvania

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1885.			
Dec.	7	Perthes, Justus, Geographical Institution, Gotha, Germany.	Two copies of pamphlet on telegraphic longitudes, and remarks on the connection of the American and European systems of longitude.
	7	Williams A. L. Surveyor, Aiken, S. C.	Magnetic declination at Aiken and law of change since 1730.
	8	Bogart, J. P.	Tracing of Calves Island, Long Island Sound.
	10	Sherman, Hon. John U. S. Senate	Index map, of the series published and proposed, of the District of Columbia.
	12	Parke, Samuel	Tracing of shoals off Watch Hill Point.
	12	Powell, J. W. Director U. S. Geological Survey	Description of station Paddy, Virginia, and geodetic data of stations Currahee, Skitt, and Sawnee, South Carolina.
	15	Newcomb, Prof. S., Superintendent of Nautical Almanac.	Geographical position of Chappe's transit of Venus station of 1769, at San José, Lower California.
	15	Bartlett, Commander J. R., Hydrographer, Navy Department.	Results of triangulation, vicinity of San Diego, Cal., and position of boundary monument.
	16	Pierrepont, J. J., Brooklyn, N. Y	Magnetic declination at Sandy Hook.
	17	Powell, J. W., Director U. S. Geological Survey	Description of station Crossville, Tenn.
	17	Harkness, Prof. W., U. S. Naval Observatory	Approximate value for longitude of astronomical observatory in Lafayette Park, San Francisco, Cal.
	18	Lockwood, Capt. D. W., U. S. Engineers	Copies of Appendices 6 and 7, Coast and Geodetic Survey Report for 1884.
	21	Newcomb, Prof. S., Superintendent of Nautical Almanac	Geographical positions of stations Basking Ridge, N. J., Wilmington, Del., and Newbury, Mass.
	21	Powell, Capt. Charles F., U. S. Engineer Office Portland, Oreg.	Description of Coast Survey bench-marks at Cathlamet, Oak View, Vancouver, and Kalama, Wash., and Saint Helen's and Rainier, Oreg., with reference to the plane of mean lower low water for all but Kalama and Rainier.
	22	Wheeler, Capt. G. M., U. S. Engineers	Areas covered by topography in the several States and Territories.
	26	Hart, F. S., Civil Engineer, Lowell, Mass	Remarks on changes in the local defections of the plumb-line and intensity of gravity due to changes of density or displacement of masses in the earth's crust or in its interior.
	26	Holmes, W. H., Philadelphia, Pa	List of geographical positions in Virginia and West Virginia, as determined by the Survey.
	29	Van Antwerp, Bragg & Co	A number of geographical positions in Pennsylvania.
	29	Wheeler, Capt. G. M., U. S. Engineers	Astronomical, geodetic, and magnetic statistics of the Coast and Geodetic Survey up to July 1, 1885.
1886.			
Jan.	2	Gill, J. J., Bros. & Co., Steubenville, Ohio	Geographical positions of Steubenville, Ohio, and of Wheeling W. Va.
	2	Wheeler, Capt. G. M	Statistics of unpublished topographical and hydrographical surveys.
	4	Dyke, E. G., Crescent City, Fla	Identification of two stars.
	4	Wilcox, J. M	Proof of chart No. 176 and chart No. 16, with hand additions.
	6	Trautwine, J. C., jr. Civil Engineer, Philadelphia, Pa	Length of a nautical mile and information respecting its definition.
	7	Van Antwerp, Bragg & Co., Cincinnati	Notes on State boundary of Pennsylvania.
	8	Bauman, William, Civil Engineer	Tracing of plane-table sheet in vicinity of Cape Charles City.
	9	Trautwine, J. C., jr., Philadelphia, Pa	Information concerning United States standard weights, and the relation between the troy and avoirdupois pounds.
	11	Cook, Prof. George H., State Geologist of New Jersey, New Brunswick, N. J.	Information relative to the law restricting the furnishing of sets of standards to the States.
	11	Hoge, F. L., City Engineer, Wheeling, W. Va	Position of astronomical station at Wheeling.
	11	McLeod, C. H., McGill College Observatory, Montreal, Canada.	Probable error of the determination of longitude of Harvard College, Massachusetts.
	12	Dustan, J. H., Calera, Ala	Magnetic declination at Calera, Ala., and changes of declination since 1819.
	14	Powell, J. W., Director U. S. Geological Survey	Geographical positions in Eastern Tennessee.
	15	Hunking, A. W., Assistant Engineer Canals, Merrimac River.	Twenty-six geographical positions with azimuths and distances of triangulation points in New England.
	15	Porter, J. W., Washington	Heights of bench-marks B and D, at Williamsport and Point of Rocks, Md.
	16	Brown, L. W., New Orleans, La	List of weights and measures constituting a set of State standards and estimate of cost.
	16	Ziegler, W., New York	Projection on plane-table sheet of Coney Island.
	18	The Chief of Engineers, U. S. A.	Tracing of hydrographic sheet, mouth of Rio Grande del Norte.
	18	Fairchild, Hon. C. S., Assistant Secretary of the Treasury, Washington, D. C.	Information as to Congressional enactment on subject of standard weights and measures; also value of standard gallon and description of mode of testing the same; also information as to where th United States standards are kept.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1886.			
Jan.	18	Dillon, John, Lawrence, Mass	Information concerning purchase of weights and measures and their subsequent adjustment and verification.
	20	Brooks, C. C., Baltimore, Md	Copy of Captain Kater's Report on Comparison of Standard Troy pound with British Standards.
	20	Symons, T. W., Captain of Engineers, office Washington Aqueduct.	Description and height above the ocean of the bench-mark near the Great Falls of the Potomac.
	23	Vermeule, C. C., Geological Survey of New Jersey	Geographical positions on the Delaware River, above Philadelphia, and geodetic data of line Mount Holly to Apple Pie Hill.
	25	Bingham, T. A., Lieutenant U. S. Engineers, Missouri River Commission.	Height of bench-marks at Saint Louis and Etlah, Mo.
	25	Miller, Col. L. P., South Carolina, Metropolitan Hotel, Washington, D. C.	Tidal relations of Winyah Bay and Santee River, South Carolina, at mouth of Mosquito Creek.
	25	Zeigler, W., New York	Comparative map of Coney Island, Rondout Harbor, and Hudson River, vicinity of Rondout Creek.
	26	Lindsley, Hon. J. G., M. C	Three hydrographic tracings made for Messrs. P. & C. F. Cantine, of Rondout, N. Y. (1) Rondout Harbor from Sleight's Ferry to entrance to Delaware and Hudson Canal, 1868. (2) Rondout Harbor between entrance and Sleight's Ferry, 1860. (3) Hudson River, vicinity of Rondout Creek, 1860.
	26	Cook, Prof. George H., State Geologist, New Jersey	Elevation of bench-marks at Absecon Light-house, and at Cape May, New Jersey.
	26	Powell, J. W., Director U. S. Geological Survey	Geographical positions, azimuths, and observed directions of a number of geodetic points in the valley of Sacramento River, California.
	28	Perkins, Mr., Librarian Public Library, San Francisco	List of standard works on geodesy and allied subjects.
	28	Smith, Henry, Saint John, Me	Tracing of part of Cape Elizabeth.
	30	Bingham, T. A., Lieut. U. S. Engineers, Missouri River Commission.	Height of bench-marks and description of line of geodesic leveling between Saint Louis, and Etlah, Mo.
Feb.	2	The city of Philadelphia	Tracing of Delaware River, from the mouth of the Schuylkill to Gloucester Point.
	3	Todd, D. P., Director, Amherst Observatory	Geographical position of observatory.
	5	The city of Philadelphia	Lettering on charts of Delaware River, showing port-warden lines of 1886.
	5	Hewins, James	Tracing of part of Nantasket Island.
	8	McLeod, W. D., Jackson, Alaska	Concerning purchase, adjustment, and verification of standard weights and measures.
	9	Philips, Prof. A. W., Yale College, Connecticut	Explanation of diurnal inequality in tide table for New London, Conn., 1886.
	10	Hazen, General W. B., Chief Signal Officer	Height of bench-marks between Saint Louis, and Etlah, Franklin County, Missouri.
	12	Dement, R. S., U. S. Surveyor-General, Salt Lake City, Utah.	Geographical position of astronomical station at Salt Lake City and relation to the survey by the General Land Office.
	13	Powell, J. W., Director U. S. Geological Survey	Abstract of horizontal angles at three stations in Tennessee, 1885.
	13	Cook, Prof. G. H., State Geologist, New Jersey	Tracing of topography between Princeton and Trenton, N. J.
	27	Bogart, J. P., Engineer Connecticut Shellfishery Commission, New Haven, Conn.	Geographical position of Old Field Point Light-house.
Mar.	1	Baker, Thomas R., State Normal Schoool, Millersville, Pa.	Magnetic declination at Philadelphia, Saint Louis, and San Francisco, in 1886.
	3	Kimball, G., Engineer, Newburg, N. Y	Geodetic data respecting triangles formed by stations Bear, Mount Dickerson, High Tor, and Ryder.
	5	O'Brien, R. E	Tracing of topography and hydrography from Indian River Inlet to Eden, Brevard County, Fla.
	8	Hoyt, Fogg & Denham, 193 Middle street, Portland, Me.	Copies of United States Tide Tables for Portland and Boston for January, February, and March, 1887.
	8	Weil, N., Cincinnati, Ohio	Geographical positions of twenty-nine cities in the United States.
	9	Johnson, Prof. J. B., Washington University, Saint Louis, Mo.	Remarks on the base-line in the American Bottom, Illinois, measured in 1872.
	10	Powell, Maj. J. W., Director U. S. Geological Survey, Washington, D. C.	Description of seven tidal bench-marks in the region of Cape Cod, Nantucket, and Martha's Vineyard.
	11	Superintendent West Point Military Academy	Geodetic results of the triangulation in the vicinity of West Point, geographical positions and description of stations.
	13	Todd, Mr. D. P., Director of Amherst Observatory	Geographical position of observatory and other objects in Amherst and North Hampton.
	13	Powell, Maj. J. W., Director Geological Survey	Description of tidal bench-mark at Edgartown, Mass.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1886.			
Mar.	13	Superintendent U. S. Military Academy, West Point, N. Y.	Description of tidal bench-marks at West Point and Verplanck's Point, New York.
	17	Forsyth, James M., Lieutenant Commander U. S. N., Navy-Yard, League Island, Pennsylvania.	Time of low water at Fort Sumter, South Carolina, nights of July 2 and 3, 1864.
	19	Holden, E. S., Director Lick Observatory, California......	Geographical position of the observatory on Mount Hamilton and surrounding stations.
	19	Wieheman, E., Washington, Hempstead County, Ark	Magnetic declination at Washington, Ark.
	19	Nader, John, Architect and Civil Engineer, Madison, Wis	Information as to published and unpublished data on Arctic tides.
	20	Wharton, Capt. W. J. L., Royal Navy, Admiralty Office, London.	Explanation as to time reckoning at tidal stations Honolulu, Saucelito, and Saint Paul.
	25	Queen, J. W., & Co., Philadelphia........................	List of weights and measures constituting a State set of standards.
	27	Gillespie, G. L., Major of Engineers, Boston, Mass........	Position of trigonometrical station "Salwages," off Rockport, Me.
	30	Knapp, H. T., New York	Tracing of hydrography of Coney Island.
	31	Bogart, J. P., Engineer Shellfishery Commission of Connecticut.	Description of stations Round Hill and Round Hill 2.
	31	Powell, J. W., Director Geological Survey	Descriptions and geographical positions of three stations in West Virginia.
Apr	1	...... do..	Geographical positions of forty-one stations in Virginia and West Virginia.
	2	Langerman, A. B., The New York and Texas Land Company, Austin, Tex.	Three pamphlets relating to magnetic declination in Texas.
	5	Powell, J. W., Director Geological Survey	Fifteen geographical positions in Northern Georgia and Alabama.
	6	Bogart, J. P..	Projection vicinity of Bridgeport.
	7	O'Harrell, I., Greenville, Tenn	Information concerning the law regulating the distribution of standard weights and measures.
	8	Brewer, H. W., U. S. Signal Office	Height of bench-mark near North Vernon, Ind.
	10	Powell, J. W., Director Geological Survey................	Eleven geographical positions in the vicinity of Frederick, Md.
	12	Schwatka, Lieut. F., New York...........................	Coast and Geodetic Survey pamphlets on terrestrial magnetism.
	12	Director of the Magnetic Observatory, Parc St. Maur, near Paris.	Four Coast and Geodetic Survey pamphlets on terrestrial magnetism.
	12	Smith, W. E., Assistant Secretary Treasury..............	Copy of comparative map of Rockaway Inlet.
	14	Cook, Prof. George H., State Geologist, New Jersey	Tracing of Barnegat Inlet.
	14	Gardiner, J. H., Newburg	Formula for computing geodetic latitude and the length of a degree of latitude and longitude.
	14	Brown, Allan D., Commander, U. S. Naval Observatory...	Longitude of Wheeling, W. Va.
	15	Powell, J. W., Director Geological Survey............. ...	Ten distances and twenty azimuths of lines in West Virginia.
	16	War Department..	Tracing of topography of part of "West Point reservation."
	20	Shedd, J. W., Civil Engineer, Providence, R. I	Geographical positions and descriptions of eight trigonometrical points in Rhode Island.
	21	Vermeule, C. C., Topographer Geological Survey of New Jersey.	Geodetic data for two primary triangulation stations in New Jersey.
	24	Powell, J. W., Director Geological Survey................	Geographical position of the Fairfax stone, Maryland and West Virginia boundary.
	24	Crowell, H. J., Boston	Tracing of shore of Buzzard's Bay from the head of Ancoot Bay to Weweantic River.
	26	Stearns, Mr. F. P., Executive Engineer, Engineer's Department, Boston, Mass.	Date and height of all tides at Charlestown navy-yard, Boston, Mass., rising more than 12¼ feet above mean low water during eighteen years between 1847 and 1865.
	27	Mahon, G. C	Tracing of three plane-table sheets, vicinity of Puget Sound.
	27	Powell, J. W., Director Geological Survey................	Three latitudes on the southern boundary of Pennsylvania west of the Maryland line.
May	1	Fairbanks, E. & T., & Co., Saint Johnsbury, Vt..........	Value of ten sets of standard weights determined for them by this Bureau.
	4	Dunn, Hon. P., M. C., House of Representatives, Washington, D. C.	Information concerning setting up of standard balance at Little Rock, Ark., and concerning preservation of standards.
	4	McElroy, J. G., Aspen, Pitkin County, Colorado.	On relation of catenary to tape and wire measures.
	4	Winslow, A., Engineer N. and S. Boundary, Raleigh, N. C.	Table of differential magnetic declination for any tenth year, between 1730 and 1900, for locality of boundary near Charlotte.
	7	Powell, J. W., Director U. S. Geological Survey...... ..	Positions of stations Sugarloaf and Stabler, Md., their distances and mutual azimuths.
	8	Cook, Prof. G. H., State Geologist of New Jersey	One hundred and fifteen geographical positions and descriptions of stations between Salem Creek and Maurice River, New Jersey.
	8	Baird, Prof. S. F	Map of limits of Gulf Stream.

APPENDIX No. 3—Continued.

Date.		Name.	Data furnished.
1886.			
May	8	Mallory, Capt. J. C., U. S. Engineers	Tracing of Barnegat Inlet.
	10	Keelogg, Judge	Two comparative tracings of Rockaway Inlet.
	12	Armistead, C. P., E. L. Asylum, Williamsburg, Va	Magnetic declination at Williamsburg and annual change.
	13	Stone, Prof. O., Director McCormick Observatory, University of Virginia.	A list of resulting north polar distances of forty-five stars from various catalogues.
	14	Lawver, Dr. W. P., Assayer of the Mint. Washington, D. C.	Papers on American standards of length and history of the Mint troy pound, and the three troy standards of this office.
	15	Director U. S. Geological Survey	Two geographical positions and an azimuth near the Missouri and Kansas boundary.
	17	Lynch, Edward	Tracing of vicinity of Point Lobos, California.
	18	Moreaux, Charles, Director of Parc du St. Maur Magnetic Observatory near Paris.	Magnetic traces and hourly values of magnetic declination, horizontal and vertical force at Los Angeles during the storm of January 9, 1886.
	19	Docteur C. St. Jean-de-Lutz, Basses Pyrénées, France	Copy of Appendices Nos. 12 and 13 on terrestrial magnetism.
	21	Williams, A. L., Surveyor, Aiken, S. C	Magnetic declination at Aiken in December, 1885.
	22	Guild, W. B., Boston, Mass	Concerning adjustment, verification, and stamping of standard weights.
	24	Buisse, Mr. L. B., No. 40 West Nineteenth street, New York City, N. Y.	Tidal data for Quogue, Long Island.
	25	Chief of Engineers, U. S. A	The geographical position of the two Light-houses on Thatcher's Island, Massachusetts.
	26	Gardiner, J. H., Newburg, N. Y	Explanation of geographical positions published by the Coast and Geodetic Survey with regard to the change of spheroid of reference and accumulation of astronomical data.
	27	Kimball, G., Newburg, N. Y.	Description of Hampton station, New Hamburg.
	27	Keith, Mr. Reuel, No. 1434 Q street northwest, Washington, D. C.	Copy of manuscript tide predictions for Philadelphia for 1887.
	29	Fairbanks, E. & T., & Co., Saint Johnsbury, Vt	Value of two weights tested for them by this Bureau.
June	2	Kelley, Mr. Allen P., Managing Editor Daily Globe, 24 Court Square, Fall River, Mass.	Constants for deriving times and heights of tides at Fall River from the predictions for New York.
	3	Wharton, Capt. W. J., Royal Navy, Admiralty Office, London, S. W., England.	Time reckoning at Honolulu tidal station; extract from letter from Hawaiian officials forwarded.
	3	Taylor, H. R., Machias, Me	Height of Manomet Hill, Massachusetts.
	3	Gardiner, James H., Newburg, N. Y	Geographical positions and geodetic data for three positions near Newburg.
	5	Lorine, M., Yonkers, N. Y	Tracing of east side of Hudson River from Peekskill to Anthony's Nose.
	8	Chief Signal Officer U. S. A	The magnetic declination for July, 1886, at one hundred and seventy-four Signal Service stations.
	9	Ewell Dr. M. D., Chicago, Ill	Information concerning standards of the International Bureau of Weights and Measures.
	16	Bacon, Charles A., Director Beloit College Observatory, Beloit.	Eleven geographical positions and geodetic data for positions in the vicinity of Beloit and of Rocton and Rockford, Ill.
	17	Lorine, M., Department of Public Works, Yonkers, N. Y.	Twenty-five geographical positions on or near the boundary line between New York and Connecticut.
	18	The Light-House Board, Treasury Department	Magnetic declinations at New London for the years 1817 and 1833 and the present time.
	21	Phillips, Prof. A. W., Yale College, Connecticut	Tables for deriving times and heights of tides at New Haven from the New London predictions, with tidal bench-marks in and near New Haven.
	25	Blackford, E. G., Survey of Oyster Territory, New York	Thirty-six geographical positions and geodetic data of stations on the southeast side of Staten Island, New York.
	25	Director of the Geological Survey	Geographical positions of two stations in Kansas, with descriptions.
	26	Pollard & Dodge, San Francisco, Cal	Tracing of Tillamook Bar, 1885.
	28	Blackford, E. G., Survey of Oyster Territory, New York	Description of trigonometrical stations southeast side of Staten Island, New York.
	30	Britton, H. C., Augusta, Ga	Information concerning purchase, adjustment, and verification of standard weights and measures.
	30	Guild, W. B., Boston, Mass	Value of sets of gram and grain weights determined for him by Bureau of Weights and Measures.

APPENDIX No. 4.—1886.

REPORT OF THE ASSISTANT IN CHARGE OF OFFICE AND TOPOGRAPHY FOR THE YEAR ENDING JUNE 30, 1886.

UNITED STATES COAST AND GEODETIC SURVEY OFFICE,
Washington D. C., June 30, 1886.

SIR: I have the honor herewith to submit my Annual Report for the Office, with the Reports from each division thereof.

On July 24, 1885, the Superintendent of the Survey was suspended, and the Assistant in charge of the Office and Topography, the Disbursing Agent, the Chief Mechanician, and the Electrotyper dismissed. The Superintendent subsequently resigned, and the Assistant in charge of the Office, who had been dismissed when performing that duty, was reinstated as Assistant in the Coast and Geodetic Survey, but he was not again instructed to resume duty in charge of the Office and Topography. It was owing to these changes that I was instructed, July 24, 1885, to perform the duties of Assistant in charge of the Office and Topography, by Superintendent Frank M. Thorn as soon as he took charge of the Survey. The ordeal through which the Survey has passed during the twelve months just ended has been a most trying one; that it has survived is, I believe, largely owing to its own merits. In the midst of, and notwithstanding all its trials, the work has gone on steadily, every objectionable business method being discarded as soon as it was found, and economies introduced wherever an opportunity offered. From various causes the duties which I have had to perform have been exacting and laborious. That I have been able to get along with them at all is due to the cordial support I have received from each and every Chief of Division in the Office, most of them trained and tried in the duties they perform so well.

On July 27, 1885, when I had been in charge of the Office three days, I was instructed to report on its condition, &c., which I accordingly did, giving facts as to some matters and opinions as to others. In two important matters my judgment was at fault. One was in regard to the force required in the field, or the normal force; the other as to that required in the Office. On each of these subjects I am now better informed, having had a year's experience in their practical management, and I make this mention in explanation of some of the recommendations which I feel it my duty to make in the best interest of the public service. I will here allude to one practice which in my opinion tended most to impair the efficiency of the Office. This was the doing of work, chiefly by draughtsmen and engravers, out of office hours, either for the Survey itself or for other parties, for which compensation was received in addition to their regular salaries. The effect of such a practice was to impair the efficiency of the persons engaged in it.

Both of my predecessors, Assistants Cutts and Boutelle, had endeavored to get rid of it, and the latter, in conjunction with Assistant Ogden had practically abolished it in the Engraving Division, but failed in the Drawing Division for lack of that support from higher authority which I have received. The practice is now entirely discontinued in every department of this office.

The Computing Division has remained under the charge of Assistant C. A. Schott. Its proficiency has been maintained, although it, with other Divisions of the Office, was seriously crippled for some months and its members kept in a state of continual excitement. An unusual number of queries have been answered as to the Magnetic Declination in the United States, which matter has now reached a point when steps should be taken to place the information which has been so carefully gathered by the Survey, through its own observers and from every other available source, in

the hands of every county surveyor and clerk of court in the United States. The adjustment and rectification of many old boundary lines depends upon authentic information as to the magnetic variation at different and often remote periods. It is therefore important to disseminate this information and render it every where accessible by its free distribution. The cost of doing this need not exceed 50 cents for each county throughout the country.

The force of the Computing Division is inadequate to the work demanded of it. At least three computers should be provided for, in addition to the present force, at an average salary not exceeding $1,200 each. This force, with such help as could be had from members of the normal force temporarily unemployed in the field, would in a few years bring the work up to date.

The valuable contribution of magnetic data by Lieutenant Greely's Polar Expedition has been prepared for the press.

Assistant Schott's interesting report of the operations of the Computing Division is herewith transmitted.

The Drawing Division: Mr. W. T. Bright was clerk and practically at the head of the Drawing Division to September 30, when he ceased to be longer connected with the Survey. Mr. T. J. O'Sullivan was then placed at its head, where he remained until his death, March 5, 1886, since which time it has been in charge of Assistant E. Hergesheimer. The work of looking up, arranging, and cataloguing the various drawings, sheets, &c., which was begun by Mr. O'Sullivan, has been continued by Mr. Hergesheimer, whose extensive knowledge and great skill in all matters pertaining to the care of original sheets and the production of drawings and charts has been of great service to the Office. I take great pleasure in acknowledging the skill of Mr. Hergesheimer and his valuable assistance, and beg to call your attention to the fact that such skill and knowledge as his would be but poorly recompensed even at a salary of $3,000 per annum.

The force of skilled draughtsmen is entirely inadequate for the work that ought to be performed. At least six young men should be added to the force, at average salaries not exceeding $1,200 per annum, to be increased as they gain in proficiency. They should all be of the class from which draughtsmen for photolithographic work are recruited. We have now enough of mediocrity. The force with the addition indicated would, with such assistance as could be rendered by the members of the normal force not engaged in field work, from time to time be able to produce some of the charts for which we have the field-notes now on hand, and of which the public is deprived of the use for want of force to get them out.

Endeavoring to carry out my ideas of economy, I immediately on taking charge of the Office began to look for competitors in photolithographing such of our charts as we wished to publish by that process. With this aim I wrote to all the leading firms within easy reach, submitting the drawings and asking estimates on one or two of the simpler jobs. The result was a great range in prices, the bids of the firms best acquainted with the requirements of the work being very near together, while those not well acquainted were either excessively high or ridiculously low. I tried the lowest bidder once or twice, and there was an entire failure to produce anything in some of the works estimated for, and in others there was a result so poor as to be rejected entirely. Advertisement for such work is entirely out of the question, and sending the finished drawings from place to place is ruinous to them, so that I am compelled to use a wise discretion in the matter, as my predecessors have done, and employ the best until other firms come up to our standard in this class of work, so as to have a fair competition.

The Engraving Division continues under the charge of Assistant Herbert G. Ogden. That the work of this important Division of the Office was for a time seriously impaired by matters over which its Chief had no control is too true; the dismissal of the electrotyper, and the death of his assistant soon after, deprived us of all facilities in that direction for a time, but this has been, or will be, more than made up in a short time by the present increased efficiency of the electrotyping and photographing establishment. The reduction from original sheets by photography and the mounting of the photographs correct to scale has been successfully accomplished by Mr. D. C. Chapman, the electrotyper and photographer. This introduces a great saving of skilled labor, since it dispenses with the services of draughtsmen for making many reductions for engraving, which formerly occupied much time. Every economy has been practiced in the purchase of material and supplies in this division, and Mr. Ogden has been indefatigable in his efforts to lessen

expense in every direction. Inquiries into the prices and qualities of different papers for use in printing charts have been continued and are still in progress. The selection of chart papers requires great judgment, and skill in manufacture is essential; they must combine many good qualities and few manufacturers can come up to the requirements.

The force of engravers is entirely inadequate to the requirements of the Survey. We need at least four more young men, at an average salary of $1,200 per annum, to keep up with work even when the Division is relieved as much as practicable by photolithography.

The excellent arrangements made by Assistant C. O. Boutelle in the Chart Printing Room leave but little to be desired there. The work is well and economically done by the force under Mr. Frank Moore, and Mr. Ogden expresses himself satisfied.

As I have done in the case of the Drawing Division, I now in the case of the Engraving Division call your especial attention to the inadequacy of the pay of its Chief. A man of Mr. Ogden's attainments is worth $3,000 as Chief of this Division, and he ought to get it for service actually rendered.

The Instrument Division: This important Division of the Office has been much improved under the management of Mr. Andrew Braid, Assistant, who took charge of it early in August, 1885. Its expenses have been reduced in the matter of outlay, new work has been turned out in addition to the usual repairs, and I hope by the close of the present fiscal year to have a shop equal to the production of much of the expensive work that we require. To Assistant C. O. Boutelle is due the credit of having begun in the right direction in the Instrument Shop.

For want of proper books and inventories we could not readily account for the instruments belonging to the Survey, but an effort has been made to get everything entered on a set of books that have been opened; inventories have been prepared and the instruments are now all entered thereon; the general property has likewise been inventoried. This laborious duty has been performed mainly by Mr. Braid.

In addition to the labors incident to a thorough overhauling of the shop, books, and accounts of the Instrument Division, Mr. Braid has been charged with the details of the Weights and Measures Bureau, which he has mastered and performed with skill. I cannot express too strongly my appreciation of his services.

If the duties that he has performed for the Coast and Geodetic Survey are worth anything they are richly worth $3,000 per annum.

The Division needs a good clerk with qualifications necessary to enable him to assist in adjusting and testing the instruments, and the pay should be about $1,200 per annum.

The Tidal Division had been found by Assistant C. O. Boutelle to be far behindhand in its work. Mr. R. S. Avery, who had been its head for many years, resigned September 30, 1885, and was succeeded by Mr. A. S. Christie, under whose direction the records have been thoroughly overhauled, and a new era of earnest work inaugurated, about in the same line as had been prearranged by Assistant Boutelle. Owing to the calls for our tide tables as much as nine or ten months in advance, I have directed that the predictions for 1888 be completed as soon as possible, and it is hoped that the tables will be published early in January. To Mr. Christie and Mr. Shidy particular credit is due for the accurate manner in which predictions have been made and the proof read of these tables for 1887. This Division of the Office is now in good discipline, and the work systematically laid out and vigorously prosecuted. Two additional computers at average salaries of $1,000 could be profitably employed in this work.

The Miscellaneous Division has continued under the charge of Mr. M. W. Wines, General Office Assistant. He has conducted all of our business with the Government Printing Office with his usual good judgment and promptness, attended to the extensive correspondence with our Chart Agencies, and continued his improvements in this service, and has heartily co-operated with me in all efforts to introduce economies, whether in the matter of original purchase or in the economical use and good care of our property.

The Chart Room has, under his charge, greatly improved both in administration and in its accounts. Steps have been taken to guard the disposal of the charts and to enable us to account for every one printed. It entails much labor on the one man in charge, more perhaps than he can be expected to do thoroughly, but by continued efforts and the aid of a perfected system it is hoped

that Mr. Eichholtz will prove equal to the task. The messengers and laborers have been under the control of Mr. Wines, as have the office wagon and many other minor matters not involving great responsibility, but the proper management of which goes far toward facilitating business. It has at times required very close management to get the messengers and laborers' work in the Office thoroughly well done on account of the scarcity of this kind of help; and we would be crippled were these men not particularly skilled in their duties.

The Library and Archives was without a head until November 14, 1885, when Mr. Artemus Martin was appointed to the position. I had hoped that we should have a first-class arrangement of our books and data from the time he took hold of the matter, but he has proven quite unequal to the task, one spell of sickness after another having so prostrated him that he has done little or nothing to improve matters there. A very fair arrangement of the Tidal Records has been made by Mr. Duesberry, and he has re-arranged a lot of miscellaneous matter in one of the upper rooms. With this exception, the Division has made no progress.

The Accounting Division was under the charge of Mr. W. B. Morgan up to 25th July, 1885, when he ceased to be at its head, and the duty was assigned to Mr. George A. Bartlett, Disbursing Clerk of the Treasury Department. The accounts were audited in the Coast Survey Office by the Coast Survey Accountants, and on presentation, duly certified, they were paid by Mr. Bartlett. To the courtesy of this gentleman we are much indebted, and nothing has been left undone by him to facilitate our work. It has been a great burden on him and a great responsibility, for which some compensation is justly due him. The Coast and Geodetic Survey should not, in my opinion, be left without a disbursing agent. As matters now are, it is quite impossible to have a strict account of the public property kept. Great improvements have been made, but the limit has been nearly reached beyond which we cannot advance until we have a well-organized disbursing office, which shall likewise be charged with the property accounts. It will involve some expenditure, but I think it would be wise to make the outlay and be able to account for everything belonging to the Survey at any time.

Dr. W. B. French has been untiring in his efforts to facilitate the business of the Office. My increased responsibilities have been fully shared by him, and he has under my direction received and accounted to me for all of the moneys coming to hand on Coast and Geodetic Survey account. I take great pleasure in commending his zeal and fidelity and in expressing my obligations to him.

During the year the Office has lost by death the services of the following-named employés:

(1) Samuel Hein, April 13, 1886. Mr. Hein had served as Disbursing Agent of the Survey for upwards of thirty-two years. His death took place shortly after he had resigned his position as Librarian, in which capacity he had rendered service during eight years.

(2) T. J. O'Sullivan, draughtsman, March 5, 1886. For six months preceding he had been in charge of the Drawing Division.

(3) Louis Karcher, draughtsman, February 16, 1886.

(4) W. B. Mapes, acting aid, February 25, 1886, while on field service on the Florida coast.

(5) Frank Over, assistant electrotypist, February 19, 1886.

(6) Hazzard McCoy, mail messenger and driver for the Office, March 10, 1886.

(7) Richard Waters, fireman, August 30, 1885.

The statistics of work accomplished in the Office during the past year, accompanying this Report, show that notwithstanding the drawbacks and trials and loss of time consequent on the numerous investigations carried on in the building, involving of necessity some demoralization on the part of a portion of the *personnel* of the Office, there has been an amount of work accomplished which is creditable and praiseworthy. Both in quantity and quality it is fully up to the standard which has characterized our previous publications and has so often elicited high praise from all parts of the world.

I have strong hope that the coming year will show increased efficiency, and shall employ every means in my power to secure it.

Yours, respectfully,

B. A. COLONNA,
Assistant Coast and Geodetic Survey,
In charge of the Office and Topography.

Mr. F. M. THORN,
Superintendent Coast and Geodetic Survey.

REPORT OF THE COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE FISCAL YEAR ENDING JUNE 30, 1886.

COMPUTING DIVISION, COAST AND GEODETIC SURVEY OFFICE,
June 30, 1886.

DEAR SIR: In conformity with regulations I have the honor to submit the usual report of work done by the several computers and attachés to this division of the office for the fiscal year ending June 30, 1886.

The charge of the Computing Division was continued with the undersigned, and the only change in the *personnel* was that of the transfer of Mr. A. S. Christie to the head of the Tidal Division on October 1, occasioning a loss of computing force during nine months, as his place has not been filled. The computation of telegraphic longitude work had to be suspended entirely in consequence of this loss. The temporary help was very limited; Mr. W. Auhagen was attached during July; Mr. J. Nelson reported for duty October 10, and was detached November 28, 1885; Mr. J. W. G. Atkins reported for duty December 7, 1885, and resigned his position in the survey January 20, 1886; Mr. W. B. Fairfield remained with the Computing Division from January 13 to February 17, 1886; Assistant E. Smith was attached between January 13 and April 12, 1886; Assistant C. H. Sinclair was attached between February 23 and March 31, 1886; Subassistant F. H. Parsons reported for duty April 2, 1886, and continued to the close of the fiscal year. In consequence of heavy calls for copies of descriptions of stations and for geographical positions, several writers were temporarily employed.

Besides the work of directing, supervising, and reporting results of the computations performed in this Division, the preparation of data and the furnishing of professional information called for by office correspondents as well as for regular field use by the survey parties, I have computed the distances and directions of a number of positions lying in the geodetic line forming part of the boundary between Nevada and California, and nearly four hundred and five statute miles in length; have brought out a memoir on the Magnetic Dip and Intensity, illustrated by three maps of the United States showing the distribution of the magnetic dip and the distribution of the horizontal and total intensities of the earth's magnetic force; have written an article for use by the General Land Office on the magnetic declination in the United States; have written a report showing the methods and formulæ applied to the computation and least square adjustment of the "Davidson Quadrilaterals" in California, to serve as a specimen of the treatment of such large operations by the Survey; have advanced the discussion of the secular variation of the magnetic declination in the United States, preparatory to the sixth edition of this paper; and in June took up the computation, discussion, and preparation of the records for the press of the astronomical and magnetic observations made by the United States expedition to Lady Franklin Bay, 1881–'84, Lieut. A. W. Greely in command. I also made the usual annual magnetic observations in this city.

Chiefly through the labors of Mr. E. H. Courtenay, the Computing Division was able to bring out for publication the geographical positions and other geodetic data determined in the States of Massachusetts and Rhode Island since the beginning of the Survey; 1,162 points in the former, and 314 in the latter State—all based on the standard astronomical data of the Survey and referred to the surface of the spheroid known as Clarke's of 1866, and completely harmonious, the unavoidable small discrepancies adhering to all measures having been removed by dispersion through adjustment.

The work performed by each computer during the year is herewith appended in detail.

Edward H. Courtenay was chiefly engaged upon the adjustment of the various triangulations executed in Massachusetts and Rhode Island, and in preparing the geodetic results for publication. This included also a recomputation of the Borden triangulation of Massachusetts, strengthened by connection with the Coast and Geodetic Survey. He made fair progress with the work of placing the old triangulation of Connecticut and New York on standard geodetic data, and with the computation of the modern survey of the western part of Long Island Sound, 1881–'85. He also has the geographical registers under his charge, takes care of the duplicate records (astronomic, geodetic, and magnetic) of the Survey, and prepares geodetic data for field or office use.

Myrick H. Doolittle computed the new triangulation (1884) of the Delaware River above Philadelphia; prepared abstracts of horizontal directions at the primary stations Mount Diablo, Sierra Morena, Mount Bache, Mount Toro, California, and of Toiyabe Dome, Lone Mountain, Mount

Callahan, Eureka, and White Pine, Nevada; established and solved the normal equations subsisting in the Yolo Base figure, California; adjusted and placed the various triangulations in the vicinity of San Francisco Bay, 1851–'85, on standard geodetic data, and adjusted the main triangulation of Nevada between White Pine and the western boundary of the State.

Alexander S. Christie furnished star places for latitude computations, and computed the line of spirit-levels within and from the District of Columbia to Ashland, Va., 1883.

Charles H. Kummell revised abstracts of angles of the triangulations in New Hampshire, in New York, in Rhode Island, and in Connecticut, computed the triangles about Coney Island, New York, 1885; assisted in the computation of geographical positions on standard data in the States of Massachusetts and Rhode Island; solved normal equations arising from the figure adjustment in the old and new triangulations in Massachusetts, Rhode Island, and Connecticut, and attended to miscellaneous geodetic computations.

Henry Farquhar computed the following astronomical latitudes: stations Tassell, N. Y.; Cape May, N. J.; Saint Louis, Mo. (1869–'70–'81); Strasburg, Va.; Mount Toro, Cal.; Blue Buck Ridge, La.; supplied revised star places for nine latitude stations in California and prepared star places for field parties.

Alexander Ziwet revised angles of the triangulations of New Hampshire and of Massachusetts, 1884; plotted the resulting magnetic dips and the horizontal and total intensity on the magnetic charts accompanying my memoir on the subject; assisted in the solution of normal equations (Davidson quadrilaterals); revised the latitude computations of Tassell, N. Y., and of Pioche, Nev.; computed the azimuth of Carson Sink, Nev., and revised the azimuths at Mount Tamalpais, Mount Diablo, Mount Helena, Mount Lola, Round Top, Southeastern Yolo base, Northwestern Yolo base, Monticello, and Vaca, Cal.; revised the azimuth computations Hunter and Jefferson, Mo., and Keeney, W. Va.; and attended to various miscellaneous geodetic work.

John B. Boutelle had temporary charge of the Archives in July and part of August; assisted in the computations for geographical positions in New York, Massachusetts, and Rhode Island; in revision of abstracts of angles and directions and other miscellaneous geodetic work. He also assisted in copying or preparing geodetic data for field and office parties.

Philander R. Stansbury attended to the clerical duties of the Computing Division, copying reports and geographical positions for office registers, and furnishing copies of descriptions of stations for field parties.

Temporary assistance was assigned as follows:

W. Auhagen computed geographical positions and revised abstracts of angles, Massachusetts, 1884.

C. D. Gedney, copied and duplicated records.

E. A. Trescot, copied descriptions of stations and did general clerical work.

J. Nelson reduced observations of spirit-levels between Ashland and Old Point Comfort, Va., 1884.

J. W. G. Atkins attended to copying, miscellaneous revisions, and computations.

W. B. Fairfield was engaged in revising angles, triangulation of Long Island Sound and shores, 1885.

Assistant Edwin Smith computed differences of longitude in connection with Transit of Venus work of 1874, and difference of longitude Fort Selden, New Mexico, and San Francisco, Cal., 1882; also computed some magnetic observations, Alaska and Utah, 1885.

G. Herbert and C. W. Schreiner attended to special copying of geographical positions for the Pacific coast registers.

Assistant C. H. Sinclair reduced transit observations at Kansas City, Mo., 1885.

Subassistant F. H. Parsons was engaged in revising abstracts of horizontal directions, computing probable error of star places, revising geodetic computations in connection with geographical positions for the registers, and other miscellaneous work.

Yours, respectfully,

CHAS. A. SCHOTT,
Assistant in charge Computing Division.

Mr. B. A. Colonna,
Assistant in charge Office and Topography,

REPORT OF THE DRAWING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR ENDING JUNE 30, 1886.

COAST AND GEODETIC SURVEY OFFICE, DRAWING DIVISION,
Washington, September 10, 1886.

DEAR SIR: I respectfully submit the following report of the Drawing Division for the year ending June 30, 1886:

The Division continued in charge of Mr. W. T. Bright until September 30, 1885, when he was relieved by Mr. T. J. O'Sullivan, who continued in charge until his death, March 5, 1886. From March 11 to date it has been in my charge.

The following persons have continued as draughtsmen during the whole year: Messrs. A. Lindenkohl, H. Lindenkohl, C. Junken, E. H. Fowler, E. J. Sommer, P. Erichsen, E. Molkow in the Drawing Division; E. Willenbucher, F. C. Donn, and W. C. Willenbucher on duty in the Hydrographic Division, and J. H. Barker in the Miscellaneous Division.

Others were employed during parts of the year as follows: T. J. O'Sullivan, from July 1, 1885, to September 30, 1885; L. Karcher, from July 1, 1885, to February 16, 1886; C. Mahon, from October 12, 1885, to date; E. A. Trescot, from December 10, 1885, to date; E. H. Wyvill, from March 22, 1886, to date; J. Olberg, from May 13, 1886, to date; W. H. Benton, from April 15, 1886, to date.

The following persons were employed on miscellaneous and clerical duty: J. C. Barr, from July 1, 1885, to September 17, 1885; W. A. Herbert, from October 1, 1885, to March 10, 1886; A. D. Simms, from April 15, 1886, to date; F. Cadel, from October 1, 1885, to February 1, 1886; K. Lawn, from October 13, 18 5, to February 1, 1886.

Messrs. A. Lindenkohl, H. Lindenkohl, C. Junken, E. H. Fowler, and E. J. Sommer were employed upon topographical and hydrographic reductions, compilations, and projections for field and office work.

Messrs. P. Erichsen, E. Molkow, and C. Mahon were mostly employed inking plane-table sheets and drawing miscellaneous sketches.

Mr. A. Lindenkohl has kept up the Progress Sketches for the Annual Report.

Messrs. H. Lindenkohl, T. J. O'Sullivan, E. H. Fowler, E. J. Sommer, E. Molkow, P. Erichsen, and E. A. Trescot have made finished drawings for photolithographing.

Messrs. J. Olberg, E. H. Wyvill, E. A. Trescot, and W. H. Benton have made tracings of topographical and hydrographic maps and sketches.

Mr. E. H. Wyvill was employed most of the time and Mr. E. Molkow at times upon projections for field-work.

J. C. Barr, W. A. Herbert, A. D. Simms, F. Cadel, and K. Lawn were employed upon miscellaneous and clerical work.

From October 12, 1885, to April 12, 1886, Assistant C. T. Iardella was employed inking plane-table sheets and making sketches of limits of original topographical and hydrographic sheets.

During the year work was done upon the following charts and maps: On eleven general charts from 1–1200000 to 1–200000 scales; on twenty-six coast charts, 1–80000 scale; on sixteen harbor charts of various scales; on twelve charts of various scales finished drawing was done for photolithographing, of which eight were published during the year; forty-three plane-table sheets were inked wholly or in part; one hundred and four projections were made for field-work; forty-seven tracings of original surveys, topographical and hydrographic, were furnished during the year at the request of other branches of the Government and private parties.

The usual amount of verification of engraved topography was done and an average number of projects for new charts made.

Respectfully, yours,

E. HERGESHEIMER,
Assistant Coast and Geodetic Survey,
In charge of Drawing Division.

Mr. B. A. COLONNA,
Assistant in charge of Office.

DRAWING DIVISION.

Charts completed or in progress during the year ending June 30, 1886.

1. Topography. 2. Hydrography.

Numbers of charts. Series.	Numbers of charts. Catalogue.	Titles of charts.	Scale.	Draughtsman.	Remarks.
		GENERAL COAST CHARTS.			
	8a	Apprroaches to New York	1-400000	2. H. and A. Lindenkohl. 2. C. Junken.	Photolithograph, completed.
	18	Vicinity of Chandeleur Islands	1-400000	2. A. Lindenkohl	Additions.
	20	Atchafalaya Bay to Galveston	1-400000	1, 2. A. Lindenkohl	Do.
XVI	21	Galveston to Rio Grande, Tex	1-400000	2. A. Lindenkohl	Do.
		COAST CHARTS.			
1	101	Eastern boundary to Seal Islands	1-80000	1. C. Junken	Completed.
2	102	Seal Island Light to Petit Manan Island Light	1-80000	2. A. Lindenkohl. 1. C. Junken	In progress.
3	103	Mount Desert Island, Frenchman's and Blue Hill Bays and approaches.	1-80000	2. C. Junken	Do.
7	107	Seguin Island to Kennebunkport	1-80000	2. A. Lindenkohl	Additions.
14	114	Long Island Sound, eastern part	1-80000	1. A. Lindenkohl. 2. C. Junken	Photolithograph.
16	116	Long Island Sound, western part	1-80000	1, 2. C. Junken	In progress.
24	124	Approaches to Delaware Entrance	1-80000	1. A. Lindenkohl. 2. C. Junken	Do.
31	131	Entrance to Chesapeake Bay, Hampton Roads, &c.	1-80000	1. H. Lindenkohl	Additions.
32	132	No. 2, York River to Pocomoke Sound	1-80000	1. A. Lindenkohl	In progress.
50	150	Cape Fear River and vicinity, North Carolina	1-80000	2. A. Lindenkohl	Do.
54	154	Long Island to Hunting Island	1-80000	2. H. Lindenkohl. 2. C. Junken	Do.
63	163	Indian River Inlet to Jupiter Inlet, Florida	1-80000	1. E. J. Sommer	Do.
64	164	Jupiter Inlet to Hillsboro' Inlet	1-80000	1. E. J. Sommer	Do.
65	165	Hillsboro' Inlet to Cape Florida	1-80000	1. E. J. Sommer	Do.
66	166	Key Biscayne to Carysfort Reef	1-80000	2. E. J. Sommer	Additions.
89	189	Bon Secours Bay to Round Island	1-80000	2. C. Junken	Do.
90	190	Round Island to Grand Island	1-80000	2. A. Lindenkohl	Do.
92	192	Chandeleur and Breton Island Sounds	1-80000	2. A. Lindenkohl	Do.
94	194	Mississippi River from the Gulf to Grand Prairie	1-80000	2. A. Lindenkohl	Do.
112	212	From latitude 26° 33′ to the Rio Grande	1-80000	1. H. Lindenkohl	Do.
	663	Puget Sound	1-80000	1. A. Lindenkohl	In progress.
		HARBOR CHARTS.			
11	305	Pleasant Bay and Prospect Harbor	1-40000	1. H. Lindenkohl	Do.
10	306	Frenchman's Bay and Somes' Sound	1-40000	1. E. Molkow	Additions.
	352	Port of Providence	1-10000	1. E. J. Sommer	Do.
	353	Narragansett Bay	1-40000	1. E. J. Sommer	Do.
	358	Fisher's Island Sound	1-40000	1, 2. H. Lindenkohl	Photolithograph; completed.
	369	New York Bay and Harbor	1-40000	1. H. Lindenkohl.	In progress.
	379	Delaware Breakwater	1-20000	2. C. Junken	Completed.
	391	Potomac River No. 4	1-40000	1, 2. A. Lindenkohl	Additions.
	431	Charleston Harbor	1-30000	2. C. Junken	Do.
	440	Savannah River and Wassaw Sound	1-40000	1. A. Lindenkohl	Do.
	453	Fernandina Entrance	1-20000	2. A. Lindenkohl	Do.
	454	Saint John's River, Florida, entrance to Brown's Creek.	1-25000	2. A. Lindenkohl	Do.
	454a	Saint John's River, Florida, entrance to Jacksonville.	1-30000	1, 2. A. Lindenkohl	Pcotolithograph; completed.
	455a	Saint John's River, Florida, Racey's Point to San Mateo.	1-40000	1. A. Lindenkohl	In progress.
	480	Cedar Keys, Florida	1-50000	2. C. Junken	Additions.
	610a	Wilmington and San Pedro Harbors, California	1-40000	1, 2. E. J. Sommer	Photolithograph.
	621	San Francisco Bay Entrance	1-50000	2. C. Junken	Additions.
	632	Humboldt Bay, California	1-30000	1. H. Lindenkohl	Photolithograph; completed.
	641c	Columbia River No. 5, Kalama to Willow Bay	1-40000	1. H. Lindenkohl	Additions.
	643	Gray's Harbor, Washington Territory	1-40000	1, 2. E. H. Fowler	Photolithograph.
	662	Puget Sound	1-20000	1. A. Lindenkohl	In progress.

DRAWING DIVISION—Continued.

Numbers of charts.		Titles of charts.	Scale.	Draughtsmen.	Remarks.
Series.	Catalogue.				
		SAILING CHARTS.			
	684	Sea-coast and interior harbors of Washington Territory.	1-300000	1, 2. A. Lindenkohl	In progress.
	654	Washington Sound	1-200000	1, 2. A. Lindenkohl	Additions.
3	673	Santa Rosa to Point Buchon	1-200000	2. A. Lindenkohl	In progress.
7	677	Point Arena to Cape Mendocino	1-200000	2. A. Lindenkohl	Do.

REPORT OF THE ENGRAVING DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR ENDING JUNE, 30, 1886.

COAST AND GEODETIC SURVEY OFFICE,
Washington, September 15, 1886.

SIR: I respectfully submit the following report on the operations of the Engraving Division during the fiscal year ending June 30, 1886:

The statistics are as follows:

ENGRAVING.

New charts published from engravings:	
Printed from copper	5
Printed from stone	1
	6
New editions of charts from engravings	7
Sketches and illustrations from engravings	3
New charts commenced	9
New editions of charts, engravings	5
Sketches and illustrations, engravings	6
Plates corrected for printing:	
Charts	460
Sketches and illustrations	14
Unfinished plates on hand:	
Charts	43
New editions of charts	3
Sketches and illustrations	31

ELECTROTYPING.

Pounds of copper deposited	1,190
Square inches on which deposits were made	48,291
Copper plates made:	
Basso	20
Alto	22

PRINTING.

Number of impressions for—	
Chart-room	28,496
Assistant in charge	1,725
Engraving division	1,370
Hydrographic Inspector	1,092
Lithographers (transfer proofs)	61
Atlantic Coast Pilot	7,482
Total	40,226

The changes in the Office force incident to the investigation of the Survey a year ago had an appreciable effect in lessening the results of the engraving and electrotyping; but the appointment of Mr. D. C. Chapman as Electrotyper and Photographer in January has proved so satisfactory that we are now as well prepared as ever for that class of work. The resignation of Mr. E. A. Maedel in October deprived us of a first-class letter engraver, and the work of the engraving has necessarily been retarded by the loss of his services, but we may hope that the steps taken to supply this deficiency will prove effective before the close of another year.

The engravers were employed during the year principally as follows: E. A. Maedel, A. Petersen, A. C. Ruebsam, and F. Courtenay, on lettering; H. M. Knight, on lettering and sand; W. A. Thompson, H. C. Evans, and R. F. Bartle, on topography and sand; J. G. Thompson, on lettering and miscellaneous corrections and additions; T. Wasserbach, on sand and miscellaneous corrections and additions; E. H. Sipe and W. H. Davis, on miscellaneous corrections and additions; J. Enthoffer and E. J. Enthoffer, on topography.

All of the engravers in the Office were employed at different times, in addition to their regular work as specified, on miscellaneous corrections and additions and such other miscellaneous work called for, as cleaning altos and new printing plates, marking instruments, &c., although this class of work has not been so heavy as in former years, owing to the practical suspension of the electrotyping for several months and the employment of an engraver in the Instrument Shop for a short period. The correction of the standard printing plates before striking off impressions of the charts for sale by the agents continues to be a work of unceasing care and labor, contrary to the views I expressed three years ago. The changes in Aids to Navigation are so frequent that many charts require correction every three or four months, and there are very few that can safely be assumed to be correct a year after they are printed. The publication of Quarterly Notices to Mariners, recently inaugurated, is a step in the direction of affording ship-masters the means of bringing up their own charts with the most important corrections themselves, and which it is believed will eventually lead to a more detailed system of monthly or even weekly notices.

The chart printing has continued under my supervision and the immediate direction of Mr. Frank Moore, foreman of the rooms. Twenty-eight thousand five hundred copies of the charts were printed for the chart-room, the largest number ever printed for this purpose in one year; and in addition the Engraving Division has been supplied with all necessary proofs; seventy-five hundred proofs have been printed for the Coast Pilot, and the usual "transfer impressions" were made of the Progress Sketches for the Annual Report, and some printing for outside parties, including "transfer impressions" of plates of postal-route maps for the Post-Office Department, for which a charge was made.

The effort to secure a more suitable paper for the chart publications was renewed during the year. Correspondence was held with eleven manufacturers, seven of whom submitted samples. Three of the samples showed promise of improvement, but we received consignments for trial from only two manufacturers. One consignment that was desirable in many respects was not satisfactory for hand corrections; this firm are now making a second sample for trial. The other consignment showed such a high average of good qualities that the manufacturers were given an order for sixteen reams. Certain desirable qualities can only be demonstrated by actual experience with a large number of sheets, and this order having proved generally satisfactory a second order has been given. This is still far from an "ideal paper," but the manufacturers evince an interest in the matter that will probably lead to further improvement. The cost is the same as paid for the American machine-made paper heretofore used.

The presses have been in charge of Mr. Frank Moore, foreman, assisted by T. Sullivan; D. N. Hoover, assisted by J. Beck, until his transfer to the charge of a press, and then by T. J. McMahon; J. L. Smith (until his transfer to another Division of the Office), assisted by H. Dyer; and J. Beck, assisted by H. Dyer, until his transfer to another Division of the Office, and since then by G. Craufurd.

The retirement of Dr. A. Zumbrock, electrotyper and photographer, in July 1885, and the long illness and subsequent death of Frank Over, his assistant, practically suspended operations of this class for several months. Mr. D. C. Chapman was assigned to Dr. Zumbrock's duties in January. He soon mastered the details of the electrotyping, so that on April 22 I was enabled to

report to you our ability to resume work for the War or Navy Departments as heretofore. He has introduced new methods simplifying the care of the batteries and reducing waste of materials, which, with systematic attention to the work, gave us three hundred and twenty pounds deposit in one month, an amount that had never been reached before with these batteries. Mr. Chapman has also been successful in making photographic reductions and in mounting them to scale by an ingenious device of his own invention. The Photographic Gallery was assigned to my supervision in September, 1885; previous to this it had been under the immediate direction of the Assistant in charge of the Office. Experiments were soon after commenced to ascertain the practicability of making photographic reductions immediately from the original topographical sheets, and a young gentleman was appointed on trial for this purpose; his efforts, however, were not satisfactory, and some work executed in the city was also a failure, so that further experiments were abandoned and only resumed on the appointment of Mr. Chapman to the division. The availability of photographic reductions of original sheets without the intermediary tracing will be the subject of a special report when the experiments now in hand have been completed.

Mr. E. A. Maedel, engraver, resigned October 1, 1885, in preference to becoming a naturalized citizen of the United States. Mr. Maedel had been employed in the Engraving Division for twenty-eight years, and was an artist in his profession. He was not excelled in his specialty of letter engraving by any of his associates, and it may be truly said that he has left a stamp of his genius on the charts of the Survey which those who follow may well endeavor to emulate.

Frank Over, for many years assistant to the Electrotyper, and Photographer, died February 19, 1886. He had been ill with typhoid fever, and it is believed in his anxiety to resume work returned to his labors too soon after convalescence. He was a man of integrity and probity and was held in high esteem by all who knew him, especially those who had cognizance of the faithfulness of his long career in this office.

Mr. John H. Smoot has continued to perform the duties of clerk of the Division in a most satisfactory manner.

I append hereto a list of the copper plates that were completed, continued, or commenced during the year.

I remain, sir, yours, very respectfully,

HERBERT G. OGDEN,
Assistant Coast and Geodetic Survey,
In charge of Engraving Division.

B. A. COLONNA, Esq.,
Assistant in charge of Office.

Plates completed, continued, or commenced during the fiscal year ending June 30, 1886.

1. Outlines. 2. Topography. 3. Sanding. 4. Lettering.

Catalogue No.	Plate No.	Title.	Scale.	Engravers and work.
		COMPLETED.		
D	1863	Gulf of Mexico	1–2100000	2, 3. W. A. Thompson. 1, 4. J. G. Thompson.
102	1842	Sea Island to Petit Manan, for lithographic edition	1–80000	3, 4. H. M. Knight. 4. J. G. Thompson.
185	1498	Choctawhatchee Bay	1–80000	2, 3. W. A. Thompson. 4. A. Petersen and A. C. Ruebsam.
204	1316	Galveston Bay	1–80000	1, 2. W. A. Thompson. 4. E. A. Maedel, H. M. Knight, and A. C. Ruebsam.
212	1715	Latitude 26° 33′ to the Rio Grande	1–80000	3, 4. H. M. Knight. 4. E. A. Maedel and A. Petersen.
673	1800	Santa Rosa to Point Buchon	1–200000	3, 4. H. M. Knight.
		NEW EDITIONS, 1885.		
120	1785	New York Bay and Harbor	1–80000	1, 2. W. A. Thompson. 3. H. M. Knight. 4. J. G. Thompson.
177	1852	Tampa Bay	1–80000	2, 3. W. A. Thompson. 2. R. F. Bartle. 3. H. C. Evans 4. A. C. Ruebsam.

***Plates completed, continued, or commenced during the fiscal year ending June 30, 1886*—Continued.**

1. Outlines. 2. Topography. 3. Sanding. 4. Lettering.

Catalogue No.	Plate No.	Title.	Scale.	Engravers and work.
		NEW EDITIONS, 1886.		
121	1856	Sandy Hook to Barnegat Inlet	1-80000	1. W. A. Thompson. 3. R. F. Bartle. 4. J. G. Thompson and F. Courtenay.
131	1866	Entrance to Chesapeake Bay, Hampton Roads	1-80000	1, 2. Joseph Enthoffer and W. A. Thompson. 3, 4. J. G. Thompson and T. Wasserbach.
700	1886	Cape Flattery to Dixon Entrance	1-1200000	1, 4. A. Petersen.
701	1880	Dixon Entrance to Cape Saint Elias	1-1200000	1, 4. A. Petersen. 4. A. C. Ruebsam.
702	1133	Icy Bay to Semidi Islands	1-1200000	1, 4. A. Petersen.
		MISCELLANEOUS.		
	1858	Atlantic Coast Pilot chart, Coast and Inland Passage, from Charleston to Fernandina.	1-400000	4. A. C. Ruebsam.
	1701	Atlantic Coast Pilot View, entrance to North Edisto River.		4. W. H. Davis.
	1707	Atlantic Coast Pilot, approaches to Saint George's River.		4. W. H. Davis.
16	1855	Key West to Tampa Bay	1-400000	4. F. Courtenay.
102	1742	Seal Island to Petit Manan	1-80000	3, 4. H. M. Knight. 4. J. G. Thompson.
147	1861	Cape Lookout to Bogue Sound	1-80000	1, 2. Joseph Enthoffer. 4. E. A. Maedel and A. Petersen.
148	1862	Bogue Inlet to New Topsail Inlet	1-80000	1, 2. R. F. Bartle. 4. E. A. Maedel.
150	1841	Cape Fear River and approaches	1-80000	4. A. Petersen.
153	1503	North Island to Long Island, including Cape Romain	1-80000	1, 3. H. M. Knight. 4. J. G. Thompson and E. A. Maedel.
162	1844	Cape Canaveral southward to latitude 27° 41′	1-80000	3. T. Wasserbach. 4. A. Petersen and A. C. Ruebsam.
180	1746	Cedar Keys to Deadman's Bay	1-80000	3. T. Wasserbach. 4. A. C. Ruebsam.
184	1601	Saint Joseph's and Saint Andrew's Bays	1-80000	4. J. G. Thompson.
192	1537	Chandeleur and Breton Island Sounds	1-80000	4. H. M. Knight.
210	1779	Aransas Pass and Corpus Christi Bays, &c		2. W. A. Thompson.
305	1821	Pleasant Bay to Prospect Harbor	1-40000	1, 2. R. F. Bartle. 4. A. Petersen and E. H. Sipe.
379	1847	Delaware Breakwater	1-20000	3. T. Wasserbach. 4. E. H. Sipe.
600	1755	San Diego to Point Arena	1-1200000	4. E. A. Maedel.
685	1834	Admiralty Inlet	1-80000	4. A. Petersen.
690	1865	Commencement Bay	1-20000	1, 2. E. J. Enthoffer.
		NEW EDITION.		
440	1831	Tybee Roads and Savannah River	1-40000	1, 2, 3. W. A. Thompson. 4. A. Petersen.
		COMMENCED.		
124	1884	Delaware Bay and River, Delaware Entrance	1-80000	1, 2. Joseph Enthoffer. 4. J. G. Thompson.
163	1872	Latitude 27° 41′ to Jupiter Inlet	1-80000	1, 2. R. F. Bartle. 4. A. Petersen and F. Courtenay.
164	1875	Jupiter Inlet to Hillsboro' Inlet	1-80000	1, 2. Joseph Enthoffer. 4. A. Petersen.
165	1876	Hillsboro' Inlet to Fowey Rocks	1-80000	1, 2. Joseph Enthoffer. 4. A. Petersen and A. C. Ruebsam.
424	1892	Cape Fear River, from entrance to Reeves Point	1-40000	1. R. F. Bartle.
425	1890	Cape Fear River, from Reeves Point to Wilmington	1-40000	1. R. F. Bartle.
455*d*	1886	Saint John's River, Racey's Point, to San Mateo	1-40000	1. A. C. Ruebsam. 4. W. H. Davis.
641*c*	1867	Columbia River No. 5, Kalama to Willow Bay	1-40009	1, 2. H. C. Evans. 4. A. Petersen.
641*d*	1868	Columbia River No. 6, Willow Bay to Portland	1-40000	1, 2. H. C. Evans. 4. A. Petersen.
		NEW EDITIONS.		
700	1886	Cape Flattery to Dixon Entrance	1-1200000	1, 4. A. Patersen.
701	1880	Dixon Entrance to Cape Saint Elias	1-1200000	1, 4. A. Petersen. 4. A. C. Ruebsam.
702	1133	Icy Bay to Semidi Islands	1-1200000	1, 4. A. Petersen.
480	1889	Cedar Keys	1-50000	3, 4. T. Wasserbach.
311*a*	1128	Fox Islands Thoroughfare	1-20000	1, 2. E. J. Enthoffer.
		MISCELLANEOUS.		
	1893	Index Chart No. 1, Cape Sable to Barnegat	1-1200000	1, 4. Harry T. Knight.
	1894	Index Chart No. 2, Martha's Vineyard to Cape Lookout.	1-1200000	1, 4. Harry T. Knight.
	1895	Index Chart No. 3, Cape Hatteras to Saint John's River	1-1200000	1, 4. Harry T. Knight.
	1896	Index Chart No. 4, Fernandina to Dry Tortugas	1-1200000	1, 4. Harry T. Knight.
	1873	Atlantic Coast Pilot View, entrance to Perquinan's River.		E. H. Fowler.
	1874	Atlantic Coast Pilot View, Edenton and Plymouth		E. H. Fowler.

REPORT OF THE INSTRUMENT DIVISION, COAST AND GEODETIC SURVEY OFFICE FOR THE YEAR ENDING JUNE 30, 1886.

COAST AND GEODETIC SURVEY OFFICE,
Washington, September 17, 1886.

DEAR SIR: I have the honor to submit the following report of the Instrument Division for the fiscal year ending June 30, 1886:

At the beginning of the year Mr. G. N. Saegmuller was still in charge of the Division, but was relieved July 23, 1885.

In accordance with instructions I took charge August 16, and have continued to the present time.

Owing to the large number and great variety of instruments used in the various operations of the Survey, a large amount of repairing and altering is constantly required, and this has, as heretofore, constituted the main work of the mechanicians, but a considerable amount of new work has also been accomplished. The preparation of instruments for the field, including their critical examination, adjustment, and determination of constants, such as level and micrometer values, inequality of pivots, &c., has been carefully attended to, as has also the official correspondence and the keeping of the records.

The dividing engine has been thoroughly overhauled, and the missing parts supplied, and it is therefore now in good working order. It has moreover been so adjusted that closer graduations than any heretofore attempted in this Office are now possible, and an experimental two-minute graduation has been made upon a fourteen-inch circle.

A critical examination of this graduation will determine the degree of accuracy attainable, and should the result be satisfactory I will recommend that the circles of a number of our large direction instruments be thus regraduated.

It is even practicable to graduate our sixteen, eighteen, and twenty inch circles still closer, viz, to one minute.

The personal equation apparatus and the printing chronograph commenced last year are well advanced toward completion, but have been for the present set aside for more pressing work. The latter instrument I consider of doubtful utility on account of its complicated structure and consequent liability to get out of order.

It might in proper hands be useful in a fixed observatory, but is not suitable for field parties.

A machine for the more accurate and uniform grinding of the spirit levels for our astronomical and geodetic instruments has long been a desideratum, and such a one has been devised by Mr. Suess, and its construction begun. The imported levels now used are ground by hand and are necessarily expensive, and it is calculated that the cheaper production of the machine-ground levels, to say nothing of the greater accuracy expected, will in a single year compensate for the cost of the machine.

The new instruments made have been principally station transits, protractors, plane-table compasses, and minor instruments, the smallness of the force employed and our limited facilities precluding the possibility of manufacturing on a large scale. I am of opinion, however, that it would be advantageous to manufacture more of our instruments, such as theodolites, plane-tables, levels, &c. The better equipment of the shop, which I have already recommended, and the employment of efficient mechanicians only, would enable us, without much increase of force, to keep pace with the requirements of the Survey. Of course certain instruments, such as chronometers, barometers, binoculars, &c., will always have to be purchased.

The following statement shows in detail the force employed in this Division during the year and indicates the character of the work performed by each person:

Mr. E. Eshleman served during the entire year; he has acted as foreman of the shop, attended to the repairs of theodolites, meridian instruments, sextants, levels, &c.; the silvering of sextant and heliotrope mirrors; the ruling of diaphragms for transits, alidades, &c.; and has made the necessary repairs and alterations on the dividing engine. He has also graduated circles for protractors, compasses, reconnoitering telescopes, engineer transits, &c., and has rendered valuable assistance in the examination, adjustment, and testing of instruments for the field.

Mr. John Clark served during the first half of the fiscal year and was employed upon repairs of vertical circles, leveling rods, gradienters, surveyors' compasses, and magnetic instruments.

Mr. L. Fischer served during the entire year. He has attended to the repairs of chronographs, prismatic transits, binoculars, tide gauges, protractors, sextants, theodolites, and drawing instruments; has made a new compass for current indicator, new letter-gauges for the Engraving Division, new tools for instrument shop, and sundry patterns for brass castings; has set up turbine for running the dividing engine, mounted lenses and eye-pieces, and made the brass-work for new instrument stands. He has also commenced the construction of seven new three-armed protractors, repaired the tide-predicting machine, and attended to the Office clocks.

Mr. S. A. Kearney served during the entire year. He has assisted in miscellaneous repairs of heliotropes, reconnoitering telescopes, levels, and drawing instruments; has made a number of new mercury cups, plummets, and plane-table chains, and the brass-work for stands and telemeters; he has also attended to the running of the gas engine and worked upon five new station transits.

Mr. P. Vierbuchen served during the entire year. He has repaired protractors, plane tables, heliotropes, plane-table compasses, and sectors, and has made three wires for base measurement, some casting patterns, a position stand for a fourteen-inch theodolite, and five new plane-table compasses.

Mr. W. Suess served during the entire year. He has worked upon densimeters, upon a personal equation apparatus, and a new printing chronograph; repaired magnetometers, dip circles, sextants, and ships' compasses; attended to the Office batteries, ruled scales for chronographs and plane tables, and commenced the construction of the machine for grinding delicate levels. The drawings for this machine were also made by Mr. Suess.

Mr. T. Gerhard served from February 8, 1885, to the close of the fiscal year. He was employed upon miscellaneous repairs of sextants, heliotropes, reconnoitering telescopes, binoculars, and zenith telescopes, and has also made some tools for the shop.

Mr. M. Lauxman served from November 1, 1885, to the close of the year, and has repaired plane-table chains, made new pins, capstan bars, bolts, shoes, &c., and has attended to the cleaning and polishing of straight edges, drawing instruments, steel tapes, &c.

During the year the carpenter shop was transferred from the Miscellaneous Division to the Instrument Division, and this step has facilitated the prompt shipment of instruments to meet requisitions of parties in the field. Mr. H. O. French has had the immediate charge of the work of the carpenter shop, and with the assistance of Messrs. G. W. Clarvoe and S. E. Parsons has attended to the making of telemeters, stands, plane table and drawing boards, instrument cases and patterns, and boxes for transportation; also the erection of shelving and the making of book and chart cases for the Drawing Division, Engraving Division, Tidal Division, Archives, and Library, and miscellaneous repairs of the buildings.

My own time has been divided between the Instrument and Weights and Measures Divisions, both being under my charge. I have also attended to the preparation of inventories of instruments, camp equipage, and miscellaneous property of all kinds in the Office, in the field, or in the hands of parties not connected with the Survey. This was a work of some magnitude and involved a voluminous correspondence. In this work I was assisted for a time by Subassistant F. H. Parsons and during a part of June by Mr. R. C. Glascock.

Yours, respectfully,

ANDREW BRAID,
Assistant Coast and Geodetic Survey,
In charge Instrument and Weights and Measures Divisions.

Mr. B. A. COLONNA,
Assistant in charge of Office.

REPORT OF THE TIDAL DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR ENDING JUNE 30, 1886.

COAST AND GEODETIC SURVEY OFFICE,
Washington, June 30, 1886.

SIR: I have the honor to submit herewith the annual report of this division for the year ending June 30, 1886.

All tidal and meteorological records received have been inspected and registered and all duplicates filed; the proofs for the Tide Tables for the Atlantic and Pacific coasts of the United States for the year 1886 have been read; similar tables for the year 1887 have been computed and part of the proof read; tidal notes for charts have been furnished as required; tabulations of high and low waters and half-hourly ordinates, with sketches and descriptions of tidal stations and bench-marks, for the use of the hydrographic officers of the Survey, have been prepared when called for, and also all tidal information for persons not connected with the Survey.

This constitutes the unavoidable current work of the Division. In addition thereto, previous to October 1, a laborious examination of the Old Point Comfort series was made and a reduction of the Fort Conger observations was begun; and since October 1 other work has been done as follows:

The original records have been completely separated from the duplicates and reductions by filing the former in the archives and retaining the latter in the rooms of the Tidal Division; the maregrams (rolls from self-registering tide-gauges) have been arranged geographically by station, each year's record at a station in a separate package, properly labeled; the original tide-books have been arranged on shelving by section and register number, the duplicate tide books in the same order in shelf boxes; the reductions have been classified and stored in dust-proof shelf boxes provided with doors and easy of access; a register of originals has been made and filed in the Tidal Division; a set of reduction forms have been devised and adopted uniform in size (eight by ten inches) with the "computing paper" in use in the Survey; a voluminous and permanently valuable set of perforated or stencil addition forms have been prepared for the harmonic series K, L, M, N, O, P, Q, v, and u; harmonic reductions of one year's observations each have been made for New London, Fernandina, and Key West, and used as the basis of the predictions for 1887; and various short series have been reduced by non-harmonic methods.

The work of the several computers and clerks is herewith given in detail:

Mr. R. S. Avery inspected the tidal observations received, attended to the correspondence relating to tides and tide-gauges, read proof for the Tide Tables for 1886, gave considerable attention to the Old Point Comfort series, prepared tide-notes for charts, and began the reduction of the Fort Conger observations. Mr. Avery continued in charge and had general supervision of the work of the Division until September 30, when his connection with the Survey terminated by resignation.

Mr. Alex. S. Christie was put in charge October 1. He has inspected the tidal records received, attended to the correspondence and calls for tidal data and information, and aided in and had supervision of the work of the Division.

Mr. L. P. Shidy examined the Old Point Comfort series, classified and arranged the reductions and duplicate records, computed auxiliary tables for the harmonic analysis, devised stencil addition forms and assisted in their preparation, devised reduction forms, made harmonic reductions for New London, Fernandina, and Key West, made non-harmonic reductions for several stations, predicted with the machine for the Pacific coast for 1887, read proof, instructed others in tidal work, and took up the Fort Conger series. Mr. Shidy's ability, experience, and unselfish devotion to the work entitle him to high commendation.

Miss M. Thomas reduced observations at Little River, California, worked on the Old Point Comfort and Pulpit Harbor series, and copied tables. Miss Thomas was transferred from this Division October 4.

Miss C. B. Turnbull worked on the Old Point Comfort series, assisted in arranging the reductions, preparing addition stencils, copying the predictions, reading proof and preparing auxiliary

tables; read maregrams for Washington, and predicted for two principal ports for 1887 by graphic methods.

Mrs. S. M. Taliaferro, attached to this Division September 14, transferred to the drawing Division October 7, and re-transferred to this Division October 12, assisted in preparing addition stencils, copying tabulations and predictions, and reading proof, read maregrams, predicted with the machine for two principal ports, copied sketches and descriptions of tidal stations and bench-marks and the major part of the correspondence.

Mrs. M. E. Nesbitt, attached to this Division October 1, assisted in classifying reductions, copied tabulations and auxiliary tables, read maregrams, ruled forms, computed the harmonic components for New London, Fernandina, and Key West, reduced some short series by non-harmonic methods, and assisted on various miscellaneous computations.

Miss K. Lawn, attached to this Division October 1 to 13, was employed in reading maregrams.

Mr. C. W. Schreiner, attached to this Division from October 2 to November 30, was employed in arranging and indexing the original tide-books.

Mr. J. W. G. Atkins, attached to this Division November 2 to 18, was employed arranging the reductions.

Mr. J. M. Duesberry, attached to this Division December 7 to February 12, and again from March 22 to 31, was employed in arranging and indexing the original tidal records.

Mr. J. W. Whitaker, attached to this Division April 1, predicted with the machine for eight principal ports on the Atlantic coast for 1887 and assisted in the preparation of addition stencils and auxiliary tables.

Miss Paula E. Smith was attached to this Division June 30 and began reading the Eastport maregrams.

Mr. J. G. Spaulding, Tidal Observer at Pulpit Harbor, North Haven Island, Maine, has read the maregrams from his station for the current year, and also assisted on the harmonic reductions for Fernandina.

Mr. Emmet Gray, Tidal Observer at Saucelito, Cal., has read the maregrams from his station for the current year.

Mr. Fred. Sargent, Tidal Observer at Saint Paul, Kadiak Island, Alaska, has read the maregrams from his station for the current year.

I am, sir, yours respectfully,

ALEX. S. CHRISTIE,
Tidal Computer, in charge of Tidal Division.

Mr. B. A. COLONNA,
Assistant in charge of Office and Topography.

REPORT OF THE MISCELLANEOUS DIVISION, COAST AND GEODETIC SURVEY OFFICE, FOR THE YEAR ENDING JUNE 30, 1886.

COAST AND GEODETIC SURVEY OFFICE,
Washington, July 1, 1886.

DEAR SIR: I have the honor to submit herewith the usual report of this Division for the fiscal year ending June 30, 1886.

The work of the Division included, as in former years, the printing and issue of the Annual Reports and other publications of the Survey, and of all record books, blank forms, &c., used in the field-work and in the business of the Office; the correspondence with sale agents relating to the supply and sale of charts, Coast Pilots, and Tide Tables, and keeping the accounts connected therewith; the custody and issue of stationery; the general charge of camp equipage, &c., the supervision of the Office buildings, and such other special duties as were assigned from time to time. The charge and direction of work in the carpenter-shop was transferred to the Instrument Division in September last.

The Report of the Superintendent for the year ending June 30, 1884, the Tide Tables for both

the Atlantic and Pacific coasts of the United States, and Subdivision 20, Atlantic Local Coast Pilot, "Winyah Bay to Savannah, with the Inland Passage to Fernandina," which had been sent to press in the preceding fiscal year, were published. The usual distribution of the Report was made, as well as of the other publications of the Survey; to the Departments of Government, institutions, and individuals. The Appendices to the Annual Reports, published in pamphlet form, were, upon application, distributed gratuitously as heretofore. Thirteen Notices to Mariners, a list of which is embodied in this report, were issued during the year. The demand for copies of Appendix No. 12, Report for 1882 (Secular Variation of the Magnetic Declination in the United States and at some Foreign Stations, fifth edition) by county surveyors, civil engineers, attorneys at law, and others specially interested in the subject of which it treats, was so great that the edition (500 copies) was exhausted early in November, and it was necessary to reprint it. Accordingly 500 additional copies of this edition were printed. The continued calls for this paper indicate that it is regarded as a standard authority throughout the country. The Tide Tables for both the Atlantic and Pacific coasts for 1887 were sent to press.

There were distributed during the year 70 copies of the Atlantic Coast Pilot, 348 subdivisions of the same, and 108 copies of the Pacific Coast Pilot. Of the Annual Reports there were distributed 2,401 copies, as follows:

Date of report.	Domestic distribution.		Foreign distribution.		Total.
	To institutions.	To individuals.	To institutions.	To individuals.	
1851					
1852		1			1
1853	1	2			3
1854	1	2			3
1855					
1856		1			1
1857	2				2
1858					
1859	2	1			3
1860	1	3			4
1861	1	2			3
1862	1				1
1863	1	1			2
1864	1				1
1865	4	1			5
1866	5	3			8
1867	7	2			9
1868	7	2			9
1869	6	1			7
1870	13	5	2		20
1871	13	6	2		21
1872	19	6	2		27
1873	19	12	3		34
1874	21	11	4		36
1875	22	16	5		43
1876	20	18	4		42
1877	21	18	5		44
1878	24	34	5	1	64
1879	26	48	5		79
1880	32	93	4	2	131
1881	35	68	5	3	111
1882	36	84	4	2	126
1883	43	144	5	1	193
1884	549	616	189	14	1,368
Total	933	1,201	244	23	2,401

The following is a list of the publications of the Survey, with the number of copies of each, received from the Public Printer during the year:

Name of publication.	No. of copies.	Name of publication.	No. of copies.
Annual Report for 1884	3,021	No. 71.—Examination of dangers reported on the coast of Maine	1,000
Atlantic Local Coast Pilot, Subdivision 20, Winyah Bay to Savannah, with the Inland Passage to Fernandina	500	No. 72.—Chart corrections during the quarter ending March 31, 1886	1,000
Tide Tables for the Atlantic coast of the United States for 1886	2,025	No. 73.—Dangerous wreck on Charleston Bar	500
Tide Tables for the Pacific coast of the United States for 1886	1,525	No. 74.—Dangerous wreck on Charleston Bar. (Addition to Notice to Mariners No. 73.)	500
Appendix No. 12, Report for 1882, "Secular Variation of the Magnetic Declination in the United States and at some Foreign Stations." (Reprint of fifth edition)	500	No. 75.—Danger developed in the resurvey of East River, New York	500
Catalogue of Charts, 1886	1,000	APPENDICES TO THE REPORT FOR 1884.	
Tables of the Azimuth and Apparent Altitude of Polaris	200	No. 6.—Tables for the Projection of Maps on a Polyconic Development	500
Tables of Logarithms of Numbers and Antilogarithms	300	No. 7.—Formulæ and Factors for the computation of Geodetic Latitudes, Longitudes, and Azimuths (third edition)	500
Superintendent's Circular, No. 1, 1886, "Preparation and Rendition of Accounts"	500	No. 9.—Junction of the Triangulations of the Lake Survey and Coast and Geodetic Survey at Lake Ontario	500
NOTICES TO MARINERS.		No. 10.—Heights of the Stations of the Davidson Quadrilaterals from Trigonometrical Determinations	500
No. 36.—Ledges developed in the resurvey of Long Island Sound	800	No. 11.—Longitudes determined by Electric Telegraph between 1846 and 1885	500
No. 64.—Dangerous Rock developed in the resurvey of East River, New York	1,000	No. 12.—Physical Hydrography of Delaware River and Bay. Comparison of Recent with Former Surveys	300
No. 65.—Dangers developed in the resurvey of East River, New York	1,000	No. 14.—Determinations of Gravity with the Kater Pendulums	300
No. 66.—Development of bar between Thatcher's Island and Milk Island, Massachusetts	1,000	No. 15.—Gravity Research. Use of the Noddy for measuring the swaying of a Pendulum support	300
No. 67.—Ledge developed in Boston Bay, Massachusetts	1,000	No. 16.—Gravity Research. Effect of the flexure of a pendulum upon its period of oscillation	300
No. 68.—Dangers developed in the resurvey of East River, New York	1,000	No. 17.—Description of a Model of the Depths of the Sea in the Bay of North America and Gulf of Mexico	300
No. 69.—Important changes in Monomoy Passage, Massachusetts	1,000		
No. 70.—Ledge developed in Fisher's Island Sound, Connecticut	1,000		

Five thousand eight hundred and eighty-nine more charts were deposited with sales agents during the year than in the preceding year, and the increase in the total issue during the same period was 1,616 charts.

The following table shows the number of charts received in the Chart Room, the number issued during the year, the number condemned, and the number remaining on hand June 30, 1886:

On hand and received.	Number of charts.	To whom issued.	Number of charts.
On hand July 1, 1885	36,496	Executive Departments	7,879
Received during the year:		Senators and Representatives	1,050
Printed from copper plates	26,458	Sale agents	19,924
Printed from stone	6,175	Institutions	623
Returned by sale agents	1,992	Foreign Governments	341
		Miscellaneous	704
		Total number issued	30,521
		Number condemned	3,790
Total	71,121	Total	34,311

Total on hand and received		71,121
Total number issued	30,521	
Total number condemned	3,790	
		34,311
On hand June 30, 1886		36,810

Mr. Hugo G. Eichholtz continued in charge of the Chart Room, and the correction and issue of charts were made under his immediate supervision.

Mr. Freeman R. Green, besides keeping the ledger accounts with sale agents, performed useful clerical duties, and merits special commendation for the prompt, intelligent, and careful manner in which he has performed the work assigned to him.

Mr. J. H. Barker was employed in plotting buoys and light-houses, and making additions and corrections on printed charts. He made during the year 85,453 corrections on 14,744 charts.

Mr. A. Upperman, who was assigned to this Division March 1, 1886, aided in making 18,012 corrections on 5,290 charts.

Mr. James L. Smith, transferred from the Printing Division March 11, 1886, was engaged in clerical work in the Chart Room and in correcting charts and catalogues.

Miss Lily A. Mapes, who was appointed and assigned to duty in this Division September 2, 1885, colored 523,029 buoys and lights on 15,363 printed charts, and was also engaged in correcting a number of catalogues. Great credit is due to Miss Mapes for speed and accuracy in performing these duties.

Miss Mary Thomas was assigned to this Division October 1, 1885, since which time she has colored 378,310 buoys and lights on 10,059 printed charts besides correcting a large number of chart catalogues.

Miss Fannie Cadel was engaged in coloring buoys and lights on printed charts to October 1, 1885, when she was transferred to the Drawing Division.

Mr. John C. Barr, who was engaged in coloring buoys and lights on printed charts, was dismissed September 15, 1885.

Misses Oliver, Harvie, and Lawn were temporarily engaged at different times during the year, when the work was pressing, in coloring buoys and lights on printed charts.

Mr. R. T. Bassett continued in charge of the Map-mounting Room. He was employed in mounting antiquarian drawing paper on muslin for original topographic and hydrographic sheets; joining charts for Chart Room; binding quarterly proofs for the use of the Superintendent and Engraving Division; mounting charts on muslin for Office use and other purposes; varnishing tracing paper for Drawing Division; mounting and repairing original sheets, and other miscellaneous work for the Office.

Mr. W. M. Long performed the duties of janitor, and Mr. C. O. Rockwell those of watchman, throughout the whole year.

The following changes in the force of watchmen occurred during the year: Mr. John Warren resigned January 15, 1886, and was succeeded by Mr. David Parker; Mr. A. C. Whitney resigned February 7, 1886, and was succeeded by Mr. John G. Culverwell; Mr. H. W. Huber resigned April 15, 1886, and was succeeded by Mr. C. O. Rockwell, who had previously been on the Weights and Measures roll; Mr. J. H. Roeth was appointed April 16, 1886, to fill the vacancy occasioned by the promotion of Mr. Rockwell.

Two deaths of employés of the Miscellaneous Division occurred during the year, viz, Richard Waters, fireman, on August 30, 1885, and Hazzard McCoy, driver, on March 10, 1886.

The messengers under the immediate supervision of William H. Butler, Chief Messenger, and the laborers employed in the Office merit special mention for the faithful performance of their duties.

Yours, respectfully,

M. W. WINES,
General Office Assistant.

B. A. COLONNA, Esq.,
Assistant in charge of Office and Topography.

ARCHIVES AND LIBRARY, COAST AND GEODETIC SURVEY OFFICE. REPORT FOR THE FISCAL YEAR ENDING JUNE 30, 1886.

COAST AND GEODETIC SURVEY OFFICE,
Washington, D. C., October 16, 1886.

DEAR SIR: I have the honor to submit the annual report of the receipt and registry in the Archives of original and duplicate records and computations, original topographic and hydrographic sheets, and specimens of sea-bottom, turned in to the office during the fiscal year ending June 30, 1886, as herein enumerated; and of the number of books and pamphlets received in the library during the same time.

I.— *Records and Computations.*

GEODETIC WORK.

	Number of volumes.		Number of cahiers.	Total.
	Original.	Duplicate.		
Observations of horizontal angles	185	163	....	348
Observations of vertical angles	21	23	....	44
Descriptions of stations	21	20	....	41
Measurement of bases	2	....	....	2
Spirit leveling	19	16	....	35
Geodetic miscellany	17	6	....	23
Computations	....	....	145	145
Total	265	228	145	638

ASTRONOMICAL WORK.

Observations for latitude	11	9	....	20
Observations for longitude	5	11	....	16
Observations for time	12	9	....	21
Observations for azimuth	5	5	....	10
Computations	4	....	38	42
Total	37	34	38	109

MAGNETIC WORK.

	Number of volumes.		Number of cahiers.		Number of sheets.		Total.
	Original.	Duplicate.	Original.	Duplicate.	Original.	Duplicate.	
Observations for terrestrial magnetism	4	3	34	29	66	....	136
Magnetic traces	....	....	....	....	553	547	1,100
Computations	....	....	3	....	71	....	74
Total	4	3	37	29	690	547	1,310

HYDROGRAPHIC WORK.

	Number of volumes.		Number bottles of specimens.	Total.
	Original.	Duplicate.		
Observations for soundings	411	269	....	680
Observations of angles	53	31	....	84
Descriptions of hydrographic signals	8	....	....	8
Specimens of sea-bottom	....	....	252	252
Specimen books	3	....	....	3
Tidal observations	142	80	....	222
Current observations and data	27	10	....	37
Hydrographic miscellany	6	5	....	11
Total	650	395	252	1,297

Besides the records enumerated in the preceding table, the following which could not be conveniently entered therein were received and registered:

Tide rolls, 27; specimens of sea-bottom, 1 box; original current observations and data, 15 sheets, 1 package, and 5 cahiers; original hydrographic miscellany, 3 packages and 9 sheets; original chronograph sheets, 2 rolls.

The following-named records were turned into the Office by Assistant C. S. Peirce. They had not been in the Archives before, but are now duly registered. Only a small part of the work to which these records relate was done within the past fiscal year, some of it dating as far back as 1872.

Records turned in by Assistant C. S. Peirce.

	Number of volumes.		Number of sheets, original.	Total.
	Original.	Duplicate.		
Pendulum experiments and observations	181	12		193
Observations for time	28			28
Time computations and reductions	4			4
Comparisons of chronometers and corrections of sidereal clocks	4			4
Barometer observations	1			1
Micrometrical measures of scales	1	1		2
Thermometer book	1			1
Instrument corrections, &c	1			1
Spectrum meter	13			13
Leveling observations	3			3
Longitude observations	1			1
Latitude observations	3			3
Personal equation observations			11	11
Chronograph sheets			121	121
Total	241	13	132	386

Also the following, not included in the above table, were turned in by Assistant Peirce: 1 envelope, 9 rolls, 1 package, and 64 sheets of pendulum work; 2 large envelopes, containing circles, diagrams, and blanks; 1 envelope Time observations; 1 bundle of Time and Pendulum Transits; 1 sheet stars for Latitude observations; 24 sheets pendulum and Star observations; 7 boxes and 3 rolls of Chronograph sheets; 1 box fillets.

II.—*Topographic and Hydrographic Surveys.*

TOPOGRAPHIC WORK.

	No. of sheets.
Delaware River from Mayne's Ditch to New Castle, Del	1
Chandler's Bay and Chandler's River, including village of Jonesboro, Me	1
North shore of Long Island Sound, Frost Point to Norwalk River and the Norwalk Islands, Conn	1
Shore of Hempstead Bay, Long Island, N. Y	1
East Hempstead and South Oyster Bay, N. Y	1
East part South Oyster Bay, western part Great South Bay, &c., N. Y	1
Great South Bay and Oak Island Beach, N. Y	1
Machiasport and vicinity, Me	1
Bar Harbor Village, Mount Desert Island (resurvey), Me	1
Columbia River, Vicinity of Bachelor's Island, Oreg	1
Machias Bay Entrance, Me	1
Shores of Indian River, Fla., Passage, Sebastian Creek to Narrows, Fla	1
Shores of Willamette River, Swan Island to Ross Island, including Portland, East Portland, and Albina, Oreg	1
Shore of Delaware River, Saint George's Creek to Bombay Hook Light, Del	1
West shore Delaware River, Bombay Hook Light to Mahon's River Light, Del	1
West Shore Delaware Bay, Mahon's River Light to triangulation station Clark, Del	1
West Shore Delaware Bay, from triangulation station Clark, to triangulation station Plum, Del	1
New Jersey Shore, Delaware Bay:	
From the Hummocks to Egg Island Light-house, N. J	1
From near the Hummocks to New England Creek, N. J	1
Elsingboro Point to below Jacob's Creek, N. J	1
North Shore Long Island Sound, Chapman's to Hammonasset Point, Conn	1
Hammonasset Point to Guilford, Conn	1
Possession Sound, Muckilteo to Preston's Point, Hawk to Randall triangulation station, Wash. Ter	1
West Coast of Florida:	
Big Marco Pass to Cape Romano, Fla	1
John's Pass to Big Marco Pass, Fla	1
Wiggins Pass to John's Pass, Fla	1
Bowditch Point to Wiggins Pass, Fla	1
Vicinity Arroyo Hondo to Lompoc Landing, north of Point Concepcion, Cal	1
From Lompoc Landing to Shuman's Cañon, Cal	1
Hood's Canal, Wash. Ter	6

Topographic and Hydrographic Surveys—Continued.

TOPOGRAPHIC WORK—Continued.

	No. of sheets.
Hood's Canal:	
Port Gamble to Hazel Point, Wash. Ter	1
Dabop and Quilcine Bays, Wash. Ter	2
Dabop Bay, Wash. Ter	1
Annas Bay, Wash. Ter	1
Columbia River:	
From Willow Bar to foot of Hayden's Island, and the Willamette River from the mouth to the head of Swan Island, Oreg	1
Columbia City to Bachelor's Island, Oreg	1
Saint John's River:	
From Racey Point to Cedar Point, Fla	1
From Cedar Point to San Mateo, Fla	1
The New Jersey Shore of Delaware Bay from Jacob's Creek to Sea Breeze, N. J	1
North Shore Long Island Sound:	
Four Mile River to Oyster River, including mouth of Connecticut River, Conn	1
From Guilford to Johnson's Point, Conn	1
From Johnson's Point to South End, Conn	1
Gardiner's Island, Long Island Sound, N. Y	1
Plum Island and Gull Island, Long Island Sound, N. Y	1
South Shore Long Island Sound:	
Oyster Pond Point to Inlet Point, including the villages of Orient and Greenport, N. Y	1
Southold and Horton's Point, N. Y	1
Eastern part of League Island, Pa	2
East front of New York and Brooklyn from Red Hook Battery to Blackwell's Island, N. Y	1
Beach of the Gulf of Mexico from East Pass eastward, Fla	1
Part of Hoosac Mountain, Mass	1
P. T. triangulation of Nansemond River, Va	2
Coney Island, Long Island, N. Y	1
Rockaway Beach, Long Island, N. Y	1
Rockaway Beach and Barren Island, Long Island, N. Y	1
Santa Maria River, northwest to Arroyo Grande, north of Point Concepcion, Cal	1
Coast of New Jersey southward from Corson's Inlet, N. J	1
Point Sur, Cal	1
Yolo Base Line, Cal	1
Santa Catalina Island, Santa Barbara Channel, Cal	1
Shores of Laguna Madre:	
From triangulation point Peat Island to Crane Islands, Tex	1
From triangulation point Griffins to triangulation Camp No. 2, Tex	1
Port Orchard, Puget Sound, Wash. Ter	1
Part of coast between Newport Bay and San Juan Capistrano, Cal	1
Moro Bay to Toro Point, Cal	1
Rosario Strait, Deception Pass to Ship Harbor, Wash. Ter	1
Blackwell's, Ward's, and Randall's Islands, N. Y	1
Little Kennebec Bay and River, Me	1
Total	75

HYDROGRAPHIC WORK.

	No. of sheets.
Pleasant Bay from entrance to Guard Point, Me	1
Narraguagus River, Me	1
Harrington Bay and River, including Black Bay and Flat Bay, Me	1
Pico triangulation station to Castro triangulation station, Cal	1
Castro triangulation station to Breaker Point, Cal	1
Breaker Point northward, Cal	1
Dredged channel, Mobile Bay, Ala	2
Portland Canal to Cape Fox, Southeast Alaska	1
Tamgas Harbor, Southeast Alaska	1
Port Chester, Southeast Alaska	1
Wrangell Straits, Southeast Alaska	1
Vicinity of Port Simpson and northern part of Chatham Sound, Southeast Alaska	1
Portland Canal to Cape Fox and Revilla Gigedo Channel, Southeast Alaska	1
Port Tongass, Southeast Alaska	1
Revilla Gigedo Channel from Duke Point to Bold Island, Southeast Alaska	1
Mary Island Anchorage, Southeast Alaska	1
Revilla Gigedo Channel, Pennock Island to Hog Rocks, Southeast Alaska	1
Hassler Harbor, Southeast Alaska	1
Tongass Narrows, Pennock Island to Guard Island, Southeast Alaska	1
Ward Cove, Southeast Alaska	1
Revilla Gigedo Channel, Mary Island to Point Higgins, Southeast Alaska	1
Etolin Harbor, Wrangell Island, Southeast Alaska	1
Portage Bay, Frederick Sound, Southeast Alaska	1
Deep-sea soundings:	
Straits of Florida, Fla	1
Deep-sea soundings—Continued.	
Straits of Florida and New Providence Channel, Fla	1
Reconnaissance of inland passage between Peril Strait and Sitka Harbor, including Saint John Baptist Bay, Alaska	1
Reconnaissance of Peril Strait from Point Suloia to Nismeni Point, Alaska	1
San Francisco Bar, Cal	1
Straits of Juan de Fuca, Wash. Ter	1
Schuylkill River, Gray's Ferry to Rambo Point, Pa	1
Delaware Bay:	
Mispillion Creek to Murder Kill Creek, Del	1
Southeastern end, N. J	1
Entrance, N. J	1
Saco Bay, Me, from Spurwink River to Scarboro' River, Me	1
Entrance to Saco River and vicinity, Me	1
Humboldt Bay and Bar, Cal	1
Saint John's River from Racey Point to San Mateo, Fla	1
Along north shore of Long Island Sound from Southwest Ledge Light-house to Welch's Point, Conn	1
Wadmelaw and Stono Rivers, S. C	1
Upper Hood's Canal, Wash. Ter	1
Hood's Canal and Daboy Bay, Wash. Ter	1
Waccasassa Bay, Fla	1
West coast of Florida north of Cape Romano, Fla	1
Pacific coast:	
From Brushy Point triangulation point to Ussal Rock triangulation point, Cal	1
From Ussal Rock triangulation point to White Rock triangulation point, Cal	1
Pleasant River, Me	1
Gulf of Mexico off coast of Louisiana, La	1
Sabine Pass and Lake, La. and Tex	1

Topographic and Hydrographic Surveys, &c.—Continued.

HYDROGRAPHIC WORK—Continued.

	No. of sheets.		No. of sheets.
Entrance to Sabine Pass, showing location of jetties, Tex	1	Twelve-Mile Arm, called "Eighteen-Mile Arm," Alaska	1
Mermentau River, La	1	Karta Bay, Alaska	1
Calcasieu Pass, La	1	Tolstoi Bay, Alaska	1
Dixon Entrance and Clarence Strait, Cape Muzon to Moira Sound, Alaska	1	Union Bay, Alaska	1
Clarence Strait, Moira Sound to Union Bay, Alaska	1	Off Chandeleur Islands, La	1
Niblack Anchorage, Moira Sound, Alaska	1	Delaware Bay off Cape May Point	1
Chasina Anchorage, Alaska	1	Charleston Harbor Bar, S. C	1
Vallenar Bay and entrance to Tongass Narrows, Alaska	1	Total	65
Naha Bay and adjacent waters, Alaska	1		

The preceding statement shows that there have been registered in the Archives during the past fiscal year, 493 volumes of geodetic observations; 145 cahiers of geodetic computations; 71 volumes of astronomical observations and computations; 38 cahiers of astronomical computations; 7 volumes and 63 cashiers of magnetic observations; 1,100 sheets of magnetic traces; 3 cahiers and 71 sheets of magnetic computations; 1,045 volumes of hydrographic observations; 37 volumes, 5 cahiers, 1 package, and 15 sheets of current observations; 11 volumes, 3 packages, and 9 sheets of hydrographic miscellany; 252 bottles and 1 box specimens of sea-bottom; 27 tide rolls; 75 original topographic sheets; 65 original hydrographic sheets; also, 254 volumes, 221 sheets, 2 packages, 4 envelopes, 12 rolls, and 8 boxes of records relating to gravity research.

There have been received and registered during the past fiscal year 633 volumes, bound and unbound, besides periodicals and scientific publications to be bound hereafter. Of these, 213 volumes were turned into the Library by Assistant Peirce; they had not been in the Library before, and therefore appear on the register as recent acquisitions. The binding of many of these books has been badly damaged by fire and they need rebinding.

During the past fiscal year 25 volumes were bound substantially in library style at the Government bindery.

There are a number of books in the Library that need rebinding, and also many unbound works and periodicals that ought to be bound.

I was appointed Librarian November 14, 1885, the appointment taking effect November 17, 1885. Mr. T. D. Reed was in charge of Archives and Library from the beginning of the past fiscal year up to that date. He was then employed in the Archives and Library as a clerk till April 1, 1886, with the exception of a short time while he was otherwise employed in the Office and when he was absent on leave. While Mr. Reed was occupied elsewhere in the Office, Mr. William B. Mapes, since deceased, was with me a few days.

Mr. J. M. Duesberry was appointed to be a clerk in the Office on April 1, 1886, and assigned to the Archives and Library.

On June 6, 1886, I was taken sick with malaria, and with the exception of a few days, was absent during the remainder of the fiscal year. Mr. Duesberry was in charge during my absence.

Respectfully submitted.

ARTEMAS MARTIN,
Librarian and Custodian of Archives.

Mr. B. A. COLONNA,
Assistant in charge of Office.

APPENDIX No. 5.—1886.

REPORT OF THE HYDROGRAPHIC INSPECTOR FOR THE YEAR ENDING JUNE 30, 1886.

COAST AND GEODETIC SURVEY OFFICE,
Washington, October 19, 1886.

SIR: I have to submit the following report of the hydrographic work of the Coast and Geodetic Survey for the year ending June 30, 1886.

On the 15th of October, 1885, I was detailed by the honorable Secretary of the Navy for duty as Inspector of Hydrography, relieving Commander C. M. Chester, U. S. N., who was ordered to a command afloat.

At the time of his detachment, Commander Chester had been connected with the Survey for over eight years, during five of which he had been Inspector of Hydrography. His interest in the work of the Survey had been so great, and his methods of conducting the duties of this office so successful, both as regards the hydrography itself and the repairs and maintenance of vessels, that I have only endeavored, so far, to carry out the system inaugurated by him.

During the summer of 1885, the steamer Blake with the hydrographic party under charge of Lieut. J. E. Pillsbury, U. S. N., Assistant Coast and Geodetic Survey, was engaged in work on the Eastern Coast, the greater part of the season being devoted to special examinations of reported dangers in Long Island and Vineyard Sounds and on the coast of Maine. The party was also engaged in completing the hydrography of Saco Bay and approaches and Cape Split Harbor.

In July an examination of George's Bank was made by Lieutenant Pillsbury with special reference to the location of a site for a light-house, a full report of which was made to you and to the Light-House Board at the time.

Late in the fall, when it was impossible to continue with proper economy the work on the northern coast, the Blake was put in condition for carrying on the surface and subsurface current work in the Gulf Stream, off the coast of Florida, the results of the previous season having been so valuable and interesting, both to the practical navigator and to the scientist, as to make it important that the work should be continued.

Tidal stations were established at Tortugas, and the serial current observations carried on with a view of determining more accurately what had partially been determined the previous year—the relations existing between the entrance of the tidal wave to the Gulf and the velocity of the Gulf Stream.

This work requires that a vessel should anchor in water of great depth, and at present little trouble is experienced in 500 fathoms. Had the appropriation permitted, it was proposed this year to try anchoring in depths as great as 2,000 fathoms, but even with the limited means at our disposal, Lieutenant Pillsbury intends anchoring in 1,000 to 1,500 fathoms for still further investigation of this interesting subject. The detailed report of Lieutenant Pillsbury, containing much valuable and original matter, has already been laid before you.

In May, the work in the Straits of Florida having been completed, the party in the Blake began the off-shore sounding on the coast of Virginia, carrying the lines out to the 100-fathom curve. This work was continued until the end of the fiscal year.

The beginning of the year found the steamer Bache, under the command of Lieut. E. D. F. Heald, U. S. N., Assistant Coast and Geodetic Survey, on the working ground on the coast of Maine, where during the summer and fall the party finished the hydrography of Pleasant River, Machias River, and the upper portion of Machias Bay.

Upon the return of this party to New York, at the end of the season, Lieutenant Heald, having served over three years on the Survey, was detached and directed to assume his regular naval duties.

In this connection I desire to express my regret in losing the services of an officer whose tour of duty was so marked by his great interest in the work and the success attained in prosecuting all that was assigned to him.

Lieut. J. M. Hawley, U. S. N., Assistant Coast and Geodetic Survey, after finishing the work assigned him in New York Harbor, was directed to assume command of the Bache, and with that party proceeded to the coast of Louisiana, where, after running a few supplementary lines of soundings off the Chandeleur Islands, he took up the examination of Horn Island Pass.

During the remainder of the winter and spring this party was employed in executing the hydrography from North Anclote to Herring Bluff, Florida. On the 26th of May the vessel proceeded to New York to prepare for work on the coast of Maine.

The Gedney, under the command of Lieut. F. H. Crosby, U. S. N., Assistant Coast and Geodetic Survey, was employed in Delaware Bay, and executed the hydrography in Maurice River and Bay and over the shoals around Cape May Point, thus completing the resurvey of Delaware River from Philadelphia to the sea.

During the winter the Gedney was employed on the coast of Louisiana, and completed the off shore hydrography west of the Mississippi Delta to the entrance to Barataria Bay, and also executed the hydrography of Coté Blanche Bay.

The Gedney closed work in the Gulf on May 19, and proceeded to New York from Pensacola, Fla., with the schooner Matchless in tow, arriving there on May 31.

As it was important to push the work in Long Island Sound as rapidly as possible, the necessary repairs to the vessel and other preparations were made with great haste, and on June 15 she started for her new working ground.

The party on board the steamer Endeavor, under the charge of Lieut. G. C. Hanus, U. S. N., Assistant Coast and Geodetic Survey, began operations in the spring, and at the beginning of the fiscal year was still engaged on the hydrography of the lower bay of New York Harbor.

With the view of comparison with past surveys, and in order to have the most accurate obtainable data for future reference, the work on the bar was executed with greater refinement than would be necessary for the navigator alone.

During the winter the party on board the Endeavor completed the hydrography of the bar and approaches of Santee River, Dewees, Caper's, and Price's Inlets, a portion of Bull's Bay, and the main channel across Charleston Bar.

As there are few protected anchorages on the coast from which the work can be economically carried on, the Endeavor was frequently obliged to anchor in an exposed position to ride out gales of wind, an unpleasant place for a small steamer.

Early in July the schooner Ready, under command of Lieut. Sumner C. Paine, U. S. N., Assistant Coast and Geodetic Survey, left New York for work on the north shore of Long Island Sound. This work was carried on until the end of the season, when the Ready was sent to New York and Lieutenant Paine was detached and ordered to duty at the Naval Observatory.

While Lieutenant Paine's services on the Survey extended over only one summer, the records of the season's work are sufficient indication of his energy and aptitude, and it was a subject of regret to this office that he could not remain longer on the Survey.

The beginning of the year found the schooner Eagre under command of Lieut. J. M. Hawley, U. S. N., Assistant Coast and Geodetic Survey, at work in East River, New York, where work had been commenced in the spring under the appropriation of $30,000 for the resurvey of New York Bay and Harbor. This party remained in the field until November, continuing the hydrography of East River as far as Blackwell's Island. The additional dangers discovered afford ample evidence of the necessity for the resurvey of this great thoroughfare.

In November Lieutenant Hawley was relieved from command of the Eagre by Lieut. D. D. V. Stuart, and assumed command of the steamer Bache, as already mentioned, and the Eagre was sent to the New York Navy-Yard for the winter.

Early in May a party was organized on board the Eagre, under the command of Lieut. C. P. Perkins, U. S. N., Assistant Coast and Geodetic Survey, and commenced field operations in North River, continuing the work of the previous season as far as and through Spuyten Duyvil Creek. The end of the year found the vessel at College Point engaged on work in Flushing Bay.

The schooner Palinurus, commanded by Lieut. W. G. Cutler, U. S. N., Assistant Coast and Geodetic Survey, continued the work, commenced in the spring, in North River, and was employed in active field-work until the latter part of November, when the vessel was laid up for the winter, and Lieutenant Cutler, after serving successfully on the Survey for nearly three years, was detached and ordered to the U. S. S. Dolphin.

Early in April a party under the command of Lieut. D. D. V. Stuart, U. S. N., Assistant Coast and Geodetic Survey, was organized on board the Palinurus and commenced work on the north shore of Long Island Sound from Sheffield Island Light to the westward, where the party was engaged at the end of this year.

The steamer Arago, having been laid up during the summer and winter, was placed in charge of Lieut. G. H. Peters, U. S. N., Assistant Coast and Geodetic Survey, in April, who with that vessel verified the notes previously taken, and took additional notes in Chesapeake Bay and tributaries for the compilation of a Coast Pilot of those waters.

In June Lieutenant Peters was relieved by Lieut. F. S. Carter, U. S. N., and directed to assume his regular duties in the office. The Arago was then sent to New York and put in condition for work in Long Island Sound.

The schooner Drift was employed during the summer and fall, under the command of Lieut. F. S. Carter, U. S. N., Assistant Coast and Geodetic Survey, in making a series of current observations in New York Bay and Harbor. In November the vessel was sent to the Navy-Yard for the winter, and in January Lieutenant Carter was detached and ordered to the Gedney.

The steamer Daisy, a small tug transferred to this office by the Light-House Board, was employed as a tender to the field parties in New York Harbor, and was of great assistance in the work at the entrance to New York.

During the summer of 1884 the schooner Scoresby was in charge of a civilian party engaged in making current observations in New York Bay and Harbor, and was afterwards laid up at the Navy-Yard, New York.

During part of August the regular hydrographic work was suspended by all the parties working in that vicinity and simultaneous current observations were made on Sandy Hook Bar.

In March a party was organized on board the Scoresby, under the command of Lieut. Francis Winslow, U. S. N., Assistant Coast and Geodetic Survey, and commenced work in Core Sound, North Carolina, making special examinations with reference to the location of oyster-beds in that vicinity.

HYDROGRAPHY—PACIFIC COAST.

The steamer Patterson, under command of Lieut. Richardson Clover, U. S. N., Assistant Coast and Geodetic Survey, continued the survey of Southeast Alaska, commenced during the spring of 1885. Lieutenant Clover extended his work to Point Lemesurier, in Clarence Strait, before it became necessary to return to San Francisco, where the Patterson arrived October 15, 1885.

In March, 1886, Lieutenant Clover was detached from the Survey at his own request. He had inspected the building of the Patterson and after her completion had command of her on the passage around to San Francisco, where she was fitted for work in Alaska.

The results of the season's work, referred to above, were so satisfactory that it was with much regret that this office lost the valuable services of so competent an officer. His survey, now published, has received the commendation of all who have seen it and who are acquainted with the locality. To show how rapidly the Alaska work has been pushed, I will state that Lieutenant Clover completed 979 miles of the shore-line during the short season in which work can be

economically carried on in these waters. For the accuracy of the work I refer to the records and to the chart already published.

After considerable deliberation as to the best method of continuing this important survey, I recommended in January last that two vessels be sent to carry on the work, on the appropriation allowed for one party. To accomplish this it was necessary to be very economical in fitting out the expedition. This was successfully accomplished, and although the results have been very gratifying, it is to be regretted that the small appropriation 1886–'87 rendered it necessary to recall the parties before the end of the season.

The vessels detailed for the work were the Patterson, Lieut. Commander A. S. Snow, U. S. N., commanding, and the McArthur, Lieut. J. M. Helm, U. S. N., commanding, the combined party being under the direction of the former officer.

Lieutenant-Commander Snow reports, September, 1886, that he has during the present season, with the combined party under his charge, completed 1,600 miles of shore-line, leaving uncompleted in Southeast Alaska about 4,500 miles.

The survey of the Alaskan coast and waters is one of the most important works now remaining for the Coast Survey. With a view of completing the survey of the principal thoroughfares now used as rapidly as possible, the work is carried on with the intention of obtaining data for the construction of charts for the use of the navigator, showing harbors, anchorages, an accurate shore-line, and such topographical features as are of use to him.

This survey is carried on under many adverse circumstances. The density of the forests, which are almost impenetrable, renders it impossible for observers to occupy the mountain peaks without great delay; the precipitous shores, thickly wooded to the high-water mark, make the building of signals very difficult; while fogs and almost constant rains, with heavy gales, constitute a yet more serious obstacle to progress. Lieutenant-Commander Snow writes, under date of June 11, 1886, that in twenty-nine consecutive days there was not one on which rain did not fall.

The naval parties on board the Patterson and the McArthur have continued the system of triangulation from a measured base, checking with astronomical stations, and have carried on all the work of triangulation, topography, and hydrography.

The steamer McArthur, under the command of Lieut. E. D. Taussig, U. S. N., Assistant Coast and Geodetic Survey, was employed in continuing the hydrography on the coast of California south of Cape Mendocino.

The shores in this vicinity are rocky and abrupt, the country is but sparsely settled, with no defined roads and only here and there a chute for a landing, and add to this the fogs, the prevailing heavy swell and occasional severe gales, without any harbor of refuge, and you have some idea of the difficulties under which this work was accomplished. Great credit is due to Lieutenant Taussig who overcame the many obstacles that were continually presented. This party returned to San Francisco during the latter part of November, and in February Lieutenant Taussig relieved Lieutenant Commander Snow of the command of the Hassler, and Lieut. J. M. Helm, U. S. N., Assistant Coast and Geodetic Survey, assumed command of the McArthur. This party prepared for work, and in April sailed for Southeast Alaska, where, in conjunction with the steamer Patterson, already referred to, the party continued the triangulation, topography, and hydrography of the inland waters.

The steamer Hassler, under the command of Lieut. Commander A. S. Snow, U. S. N., Assistant Coast and Geodetic Survey, sailed early in August for Departure Bay, when, after coaling, she proceeded in the execution of the work assigned her, viz, off-shore hydrography south of Columbia River, Oregon, examination of the channels into and in Tillamook Bay, hydrography of Walker Island Bar and Tongue Point Bar, Columbia River.

The party was delayed by gales, rain, and smoke, and owing to the continuous bad weather was unable to connect the outside steamer lines with tne shore. The vessel returned to San Francisco in November, and after Lieutenant Taussig assumed command, in February, the party was prepared to complete the work on the coast of California south of Cape Mendocino.

April 1 the Hassler started for the working ground, and a few days later the party was engaged in active operations in the field.

In spite of the heavy rain and frequent southeasterly gales the work was prosecuted with great

vigor, and on June 18 the party arrived in San Francisco, having finished this most difficult piece of work.

The schooner Earnest, under the command of Lieut. Charles T. Forse, U. S. N., Assistant Coast and Geodetic Survey, was engaged in the survey of Puget Sound. The party arrived in the field early in the season, and at once commenced active operations. The hydrography of Hood's Canal and Port Orchard was finished before the party returned from the field, which was not until December 8, after the weather became too severe for active field operations. Early in April, the party was again in the field engaged in the hydrography of Admiralty Inlet and Port Townsend, both of which were finished by the latter part of June, when the vessel left for Possession Sound.

The chief obstacle to contend with in the prosecution of the work in Puget Sound is smoke. The yearly extensive forest fires envelop the whole country in a cloud of smoke, so that for several weeks at a time it is impossible to carry on any field-work.

The steamer Hitchcock and schooner Quick in the Gulf, the barge Beauty on the Atlantic coast, and the schooner Yukon and sloop Kincheloe on the Pacific coast, were used by civil assistants.

The Hydrographic Division has been under the charge of Lieut. J. F. Moser, U. S. N., Assistant Coast and Geodetic Survey, and to his great care and untiring energy we are mainly indebted for the accuracy of our charts, particularly in regard to changes since their issue. The co-operation of the Light-House Board, through its Naval Secretary, Commander H. F. Picking, U. S. N., is so thorough, that all changes made under the direction of the Board are immediately indicated on our charts. By recent arrangement with the Chief of Engineers, U. S. Army, we hope in the future to be able to profit by the numerous hydrographic surveys carried on by that service in connection with harbor improvements.

In December I recommended to you that a scheme prepared by Lieut. J. F. Moser, U. S. N., for a quarterly issue of a "Notice to Mariners" be carried out, and on March 31 the first of this series was issued. This notice is intended to contain in a brief space all the important changes that have been made on any chart since the preceding notice. These changes include not only new dangers, but also important changes in buoyage, new lights, &c.; in fact any addition or correction to the chart that would make it more perfect and be of interest to the navigator. These notices are also sent to the chart sales agents, so that they can have an opportunity of correcting charts on hand, or at least distributing them with charts sold. In view of the fact that they seem to be serving a very good purpose, I have to suggest that after January 1, 1887, these notices be issued monthly. It is not intended that they should take the place of the special notices issued when important dangers are discovered or developed.

The work in the draughting-room of the Hydrographic Division of this office was most satisfactorily performed by Messrs. E. Willenbucher, W. C. Willenbucher, and F. C. Donn. A tabulated statement appended will show for itself the zeal displayed by these gentlemen.

The general supervision of the work on the Atlantic Coast Pilot having been assigned to the Hydrographic Inspector, with your approval I detailed for this duty and placed in immediate charge of it at the beginning of the fiscal year Lieut. George H. Peters, U. S. N., Assistant Coast and Geodetic Survey, who had at an earlier period served one tour of duty on the Survey.

In August and September field-work on the New England coast was carried on for purposes of verification and revision, including special hydrographic examinations where necessary. During the winter, office duties were performed in the revision of the volumes already in print and in noting the necessary corrections to bring up to date manuscript already prepared but not yet printed, as well as in the preparation of new matter. The current editions of a number of volumes of the Atlantic Local Coast Pilot being nearly exhausted, the publication of new editions in such cases has been kept in view in carrying on the revision. The changes required to bring the text up to date are many, involving much labor in which great care and accuracy are necessary. A new (third) edition of Subdivision 13, which includes the south coast of Long Island, New York Bay and Harbor, and the Hudson River, is in the hands of the printers and will soon be issued; new editions of others are in an advanced state of preparation and will soon be ready for the printer.

Lieutenant Peters again took up field-work early in April, taking charge of the steamer Arago for the collection of data in Chesapeake Bay and tributaries, in which work he was engaged until the middle of June, then returning to the office and resuming duties here. In the latter part of

November, 1885, Mr. John B. Goode, jr., was designated to assist in the Coast Pilot work, and performed the clerical and other duties assigned him most efficiently up the time of his resignation in August, 1886.

It is proposed to suspend, for the present at least, the publication of the large volumes of the Atlantic Coast Pilot, two of which, viz, Division A, Eastport to Boston, and Division B, Boston to New York, have already been issued. To meet local wants, the Atlantic Local Coast Pilot, issued in subdivisions, each comprising a limited portion of the coast, may well be continued; a volume of this series, treating of Chesapeake Bay and tributaries, and others, covering the coast to the southward of Savannah, are now in hand, the coast from Cape Henry to Savannah being included in subdivisions 19 and 20, already issued. The demand for the Local Coast Pilot is sufficient to indicate that it supplies a special want, but its bulk and its minuteness of detail render it unsuitable for general use. For this purpose a Coast Pilot should be prepared which should include the entire Atlantic coast in one volume. Our naval vessels now have to be supplied with a general work of this nature, issued by a private firm; while this is a useful publication, it does not appear to meet their needs fully. For the general treatment of the Atlantic coast, a method involving new features has been devised by Lieutenant Peters. Sample pages illustrating the proposed method have recently been printed, with your approval, to facilitate proper distribution for the purpose of eliciting such criticism and discussion as will tend to enhance the usefulness of the project.

The general condition of the hulls, engines, boilers, &c., of the vessels of the Survey at the end of the year was good, with a few exceptions, which will be noted.

The service on which vessels in the Survey are engaged is very severe on their boilers, at times going for months without hauling fires. Those of the steamer Gedney, after over ten years' use, were in such condition that it was decided best to put in new ones. Bids were accordingly asked for, and on the 28th of June the contract was awarded to Messrs. Spedden & McClymont, of Baltimore, Md., for $2,940. While the boilers are out of the vessel it is proposed to give her a general overhauling, it having been ascertained that many of her fastenings are in a very bad condition. The Gedney is a composite vessel, and her fastenings are of iron. Recent investigation shows that many of them are entirely eaten away by galvanic action, and it is proposed to replace them.

A new steam windlass was placed in the Gedney in December last, which adds much to the efficiency of that vessel.

In June arrangements were made for the building, at the Washington Navy-Yard, of two large steam launches. These boats when completed will be a very valuable addition to the Survey.

The Arago's decks have given considerable trouble, being too old and loose to be properly calked. The question whether she is in proper condition to warrant putting in new decks and deck-houses will have to be considered this year. She is of much service to the Survey, being comparatively inexpensive to maintain, and her light draught enables her to work in our inland sounds.

The schooner Matchless, which was turned over to the Survey in July, 1885, by the Quartermaster's Department, U. S. Army, will require, in order to place her in proper condition for use, a thorough remodeling of her interior arrangements, when she will prove a very valuable addition to our vessels.

During the winter the repairs were made to the vessels at New York by the reduced crews of those vessels. These repairs included ship carpenter's, joiner's, sail-maker's, and machinist's work, and the result was that when the vessels were required for service in the spring the amount of money expended for repairs was very small, being confined principally to skilled labor of a class not easily found among a ship's crew, such as coppersmith's and plumber's work.

On the 1st day of March I had the honor to recommend that the schooners Bache and Research be sold, as their condition was such as to render it not advisable to put them in condition for use. The schooner Silliman could properly have been brought under the same head, but although unfit for further use as a surveying vessel, she was still of great service as a store-ship for Coast Survey property at the New York Navy-Yard.

The tenders for the schooner Bache were so small that it was decided not to accept any of them, and she was, on application, turned over the Bureau of Ordnance, Navy Department.

The Research was sold at Pensacola, Fla., to the highest bidder for $227.

The steam launch Lively, now engaged in the Alaska survey, has been almost constantly in use for twelve years, and is now in such condition as to render it questionable as to the propriety of repairing her. A recent survey by a board of officers shows that she will require very extensive repairs, both to hull and to engines and boiler. It will probably be more economical to replace her by a new launch.

From the rather indefinite information that can be obtained, it seems to be necessary to make extensive repairs to the hull of the steamer Barataria, now laid up at Gretna, La. The steamer Hitchcock, laid up at the same place, also requires considerable work on both hull and engines.

In March Mr. Wyvill, who had served faithfully for nearly four years in this office, was promoted to a position in the Drawing Division, and his place has since been filled to my satisfaction by Mr. George J. Vestner.

I forward herewith tabulated statements of officers serving on the Survey, work done in field and office, &c.

Very respectfully,

W. H. BROWNSON,
Lieutenant-Commander, U. S. N.,
Hydrographic Inspector.

Mr. F. M. THORN,
Superintendent U. S. Coast and Geodetic Survey.

List of Naval Officers attached to the Coast and Geodetic Survey during fiscal year ending June 30, 1886.

Name.	Date attached.	Remarks.
COMMANDER.		
C. M. Chester	Oct. 2, 1877	Detached October 19, 1885.
LIEUTENANT-COMMANDERS.		
A. S. Snow	Aug. 1, 1883	Still in service.
W. H. Brownson	Aug. 11, 1881	Detached December 2, 1884; re-attached June 29, 1885; still in service.
LIEUTENANTS.		
E. D. F. Heald	Mar. 23, 1882	Detached November 18, 1885.
Richardson Clover	July 26, 1881	Detached March 1, 1886.
E. D. Taussig	Apr. 30, 1883	Still in service.
J. E. Pillsbury	July 13, 1882	Do.
Jefferson F. Moser	Jan. 29, 1884	Do.
Charles T. Forse	July 7, 1884	Do.
J. M. Hawley	Mar. 21, 1885	Do.
G. Blocklinger	Jan. 30, 1883	Detached March 10, 1886.
C. P. Perkins	Apr. 27, 1886	Still in service.
S. C. Paine	June 2, 1885	Detached November 24, 1885.
D. D. V. Stuart	July 10, 1885	Still in service.
Francis Winslow	Mar. 12, 1886	Do.
F. H. Crosby	Oct. 6, 1884	Do.
G. C. Hanus	Mar. 20, 1883	Do.
J. C. Burnett	Mar. 23, 1886	Do.
LIEUTENANTS, JUNIOR GRADE.		
George H. Peters	June 30, 1885	Still in service.
David Peacock	Mar. 29, 1886	Do.
J. M. Helm	Feb. 13, 1885	Do.
W. G. Cutler	Mar. 29, 1883	Detached December 9, 1885.
F. S. Carter	Apr. 23, 1885	Still in service.
B. F. Walling	Mar. 31, 1886	Do.
H. T. Mayo	May 7, 1886	Do.
Charles F. Pond	Apr. 8, 1886	Do.
DeWitt Coffman	Apr. 12, 1886	Do.
W. G. Hannum	Apr. 27, 1886	Do.

Name.	Date attached.	Remarks.
ENSIGNS.		
W. McLean	July 15, 1884	Detached October 16, 1885.
T. D. Griffin	May 2, 1883	Still in service.
F. H. Sherman	Oct. 31, 1882	Detached December 4, 1885.
J. M. Orchard	Feb. 10, 1882	Detached November 24, 1885.
J. N. Jordan	Jan. 25, 1881	Detached December 28, 1885.
A. F. Fechteler	June 24, 1882	Detached September 20, 1885.
T. M. Brumby	Dec. 21, 1882	Detached December 15, 1885.
E. E. Wright	Apr. 7, 1885	Still in service.
A. W. Dodd	Apr. 9, 1885	Do.
F. M. Bostwick	Sept. 28, 1881	Detached March 10, 1886.
A. L. Hall	May 1, 1883	Detached January 9, 1886.
P. J. Werlich	Mar. 15, 1884	Detached January 9, 1886.
Simon Cook	Sept. 22, 1885	Still in service.
R. M. Hughes	Jan. 13, 1886	Do.
W. L. Burdick	Mar. 31, 1884	Detached November 17, 1885.
W. C. Canfield	Sept. 26, 1882	Detached November 16, 1885.
A. G. Rogers	Apr. 29, 1885	Still in service.
W. P. White	Feb. 10, 1883	Do.
John H. Shipley	Apr. 7, 1885	Do.
John E. Craven	Nov. 28, 1883	Still in service.
J. H. Hetherington	June 19, 1883	Do.
C. C. Marsh	May 3, 1884	Do.
C. W. Jungen	Aug. 25, 1883	Do.
C. S. Ripley	May 4, 1885	Do.
W. J. Sears	Apr. 28, 1885	Do.
J. A. Bell	Feb. 22, 1885	Do.
D. P. Menefee	July 28, 1883	Do.
F. W. Kellogg	Aug. 23, 1882	Detached July 31, 1885.
J. L. Purcell	Mar. 26, 1886	Still in service.
William A. Thorn	Nov. 1, 1884	Detached November 2, 1885.
R. O. Bitler	Apr. 29, 1885	Still in service.
A. P. Niblack	July 2, 1884	Do.
William Truxtun	July 3, 1882	Detached October 5, 1885.
E. Simpson, jr.	Oct. 21, 1882	Detached November 29, 1885.
J. S. Watters	July 7, 1883	Still in service.
E. L. Leiper	Apr. 26, 1883	Do.

List of Naval Officers attached to the Coast and Geodetic Survey, &c.—Continued.

Name.	Date attached.	Remarks.
ENSIGNS—continued.		
J. C. Drake	Apr. 16, 1886	Still in service.
M. C. Gorgas	Oct. 26, 1882	Detached November 29, 1885.
F. R. Brainard	July 20, 1883	Still in service.
Theodore G. Dewey	June 18, 1883	Do.
G. R. French	May 4, 1883	Do.
W. P. Fletcher	May 17, 1886	Do.
Marbury Johnson	May 19, 1886	Do.
George W. Street	Aug. 31, 1885	Do.
J. M. Ellicott	Aug. 6, 1885	Detached November 10, 1885.
C. E. Sweeting	Aug. 4, 1885	Still in service.
E. E. Thurston	Aug. 7, 1885	Detached January 9, 1886.
F. A. McNutt	Oct. 15, 1884	Detached April 12, 1886.
Harry A. Field	Aug. 1, 1885	Still in service.
SURGEON.		
W. S. Dixon	Apr. 20, 1884	Detached November 28, 1885.
PASSED ASSISTANT SURGEONS.		
T. H. Streets	Mar. 19, 1884	Still in service.
F. B. Stephenson	Sept. 1, 1884	Do.
PASSED ASSISTANT SURGEONS—continued.		
David O. Lewis	Nov. 28, 1885	Still in service.
A. A. Austin	Sept. 22, 1885	Do.
W. H. Rush	June 3, 1884	Do.
ASSISTANT SURGEON.		
H. B. Fitts	Jan. 27, 1884	Detached September 21, 1885.
PASSED ASSISTANT PAYMASTER.		
J. R. Stanton	Nov. 1, 1883	Still in service.
PASSED ASSISTANT ENGINEERS.		
H. Main	May 29, 1883	Still in service.
H. N. Stevenson	Mar. 10, 1883	Do.
George Cowie, jr	Jan. 1, 1885	Do.
ASSISTANT ENGINEERS.		
E. T. Warburton	Feb. 21, 1883	Still in service.
Robert I. Reid	June 9, 1882	Do.

List of Naval Officers attached to the Coast and Geodetic Survey, June 30, 1886.

COAST AND GEODETIC SURVEY OFFICE.

Lieut. Commander W. H. Brownson, U. S. N., Hydrographic Inspector.
Lieut. J. F. Moser, U. S. N., Hydrographic Division.
Lieut. George H. Peters, U. S. N., Coast Pilot Division.
Passed Assistant Paymaster J. R. Stanton, U. S. N., in charge of naval pay accounts.

ATLANTIC AND GULF COASTS.

Steamer G. S. Blake (Atlantic Coast).—Lieut. John E. Pillsbury, U. S. N., Commanding; Ensigns T. D. Griffin, J. H. Hetherington, R. M. Hughes, F. R. Brainard, and A. G. Rogers; Passed Assistant Surgeon W. H. Rush; Passed Assistant Engineer George Cowie.

Steamer A. D. Bache (Atlantic Coast).—Lieut. J. M. Hawley, U. S. N., Commanding; Ensigns E. E. Wright, R. O. Bitler, J. E. Craven, and H. A. Field; Passed Assistant Surgeon F. B. Stephenson; Passed Assistant Engineer Hershel Main.

Schooner Eagre (Atlantic Coast).—Lieut. Charles P. Perkins, U. S. N., Commanding; Ensigns W. J. Sears and W. B. Fletcher.

Schooner Palinurus (Atlantic Coast).—Lieut. D. D. V. Stuart, U. S. N., Commanding; Ensigns W. G. Hannum and Marbury Johnston.

Steamer Gedney (Atlantic Coast).—Lieut. F. H. Crosby, U. S. N., Commanding; Ensigns J. S. Watters, C. E. Sweeting, and G. W. Street; Passed Assistant Surgeon A. A. Austin.

Steamer Endeavor (Atlantic Coast).—Lieut. G. C. Hanus, U. S. N., Commanding; Ensigns C. S. Ripley, G. R. French, and E. F. Leiper.

Schooner Scoresby (Atlantic Coast).—Lieut. Francis Winslow, U. S. N., Commanding; Lieut. Burns T. Walling; Ensign J. C. Drake.

Steamer Arago (Atlantic Coast).—Lieut. F. S. Carter, U. S. N., Commanding.

Schooner Drift (laid up at New York Navy-Yard).—Ensign A. W. Dodd, U. S. N.

PACIFIC COAST.

Steamer Patterson (Alaska Coast).—Lieut. Commander A. S. Snow, U. S. N., Commanding; Lieuts. J. C. Burnett and DeWitt Coffman; Ensigns C. C. Marsh, A. P. Niblack, D. P. Menefee, and T. G. Dewey; Passed Assistant Surgeon T. H. Streets; Passed Assistant Engineer H. N. Stevenson.

Steamer Hassler (Pacific Coast).—Lieut. E. D. Taussig, U. S. N., Commanding; Lieuts. David Peacock and Charles F. Pond; Ensigns W. P. White and C. W. Jungen; Passed Assistant Surgeon D. A. Lewis; Passed Assistant Engineer E. T. Warburton.

Schooner Earnest (Pacific Coast).—Lieut. Charles T. Forse, U. S. N., Commanding; Lieut. Henry T. Mayo.

Steamer McArthur (Alaska Coast).—Lieut. J. M. Helm, U. S. N., Commanding; Ensigns Simon Cook, J. A. Bell, J. H. Shipley, and J. L. Purcell; Passed Assistant Engineer R. I. Reid.

Number of Naval Officers attached to the Coast and Geodetic Survey vessels during the fiscal year ending June 30, 1886.

Name of vessel.	September 30, 1885.	March 31, 1886.	Name of vessel.	September 30, 1885.	March 31, 1886.
Steamer Blake	8	8	Schooner Eagre	3	1
Steamer Bache	7	7	Schooner Ready	2	....
Steamer Gedney	6	7	Schooner Scoresby	....	1
Steamer Endeavor	6	3	Schooner Palinurus	2	....
Steamer Patterson	8	8	Schooner Earnest	1	2
Steamer Hassler	7	7	Coast Survey Office	4	3
Steamer McArthur	5	5	Total	59	52

Average number 55.

Number of men attached to the Coast and Geodetic Survey vessels during the fiscal year ending June 30, 1886.

Name of vessel.	September 30, 1885.	December 31, 1885.	March 31, 1886.	June 30, 1886.
Steamer Blake	37	37	39	37
Steamer Bache	33	31	33	29
Steamer Gedney	27	26	26	27
Steamer Endeavor	20	17	19	20
Steamer Arago	2	1	5	12
Steamer Hitchcock	1	....	....	2
Steamer Daisy	8	4	4	6
Steamer Barataria	2	2	2	1
Steamer Hassler	34	33	32	23
Steamer Patterson	39	39	37	39
Steamer McArthur	29	29	28	29
Schooner Eagre	19	7	10	19
Schooner Palinurus	16	6	6	15
Schooner Drift	14	6	5	4
Schooner Ready	16	6	6	7
Schooner Earnest	15	8	7	15
Schooner Scoresby	1	4	10	16
Schooner Yukon	....	1	1	1
Schooner Silliman	1	3	3	2
Schooner Matchless	1	1	1	....
Schooner Quick	1	....	....	....
Schooner Research	1	1	1	....
Schooner G. M. Bache	2	2	2	....
Sloop Kincheloe	1	1	1	1
Barge Beauty	....	1	1	....
Total	320	266	279	305

Average number of men, 292.

RECAPITULATION.

Whole number of vessels:

Steamers	11
Schooners	10
Sloops	1
Barges	1
Total	23
Number of vessels in active service	20

This complement does not represent the actual number of officers or men in the Survey during the year, owing to the fact that some vessels were employed only a part of the time.

Average number of officers for the year 55

Average number of men for the year...292

See tabular statements preceding showing actual number of officers attached to the several vessels in service and number of officers on other duty at different periods during the fiscal year, also the number of men actually in service at the end of each quarter of the fiscal year, with the names of the vessels in which they were serving.

Names of vessels, their tonnage, &c., in the service of the Coast and Geodetic Survey, during the fiscal year ending June 30, 1886.

No.	Name of vessel.	Tonnage.	Complement of—	
			Officers.	Men.
1	Steamer Patterson	453	9	39
2	Steamer Hassler	243	7	23
3	Steamer Blake	218	8	37
4	Steamer Bache	186	7	29
5	Steamer Gedney	133	5	27
6	Steamer McArthur	112	6	29
7	Steamer Endeavor	105	4	20
8	Steamer Hitchcock (civilian party)	83	....	2
9	Steamer Barataria (civilian party)	50	....	2
10	Steamer Arago	38	1	12
11	Steamer Daisy	44	....	6
1	Schooner Eagre	202	3	19
2	Schooner Drift (laid up)	87	1	4
3	Schooner Earnest	80	2	15
4	Schooner Ready (civilian party)	80	....	7
5	Schooner Yukon (civilian party)	78	....	1
6	Schooner Palinurus	76	3	15
7	Schooner Silliman (laid up)	72	....	2
8	Schooner Scoresby	72	3	16
9	Schooner Matchless (laid up)	....	....	....
10	Schooner Quick (civilian party)	38	....	....
1	Sloop Kincheloe (civilian party)	30	....	1
1	Barge Beauty (civilian party)	28	....	....

HYDROGRAPHIC DIVISION.

Original hydrographic sheets, plotted, verified, and inked during the fiscal year ending June 30, 1886

Title of sheet.	Scale.	Draughtsman.	Remarks.
ATLANTIC COAST.			
Pleasant River, Maine, above Guard Point	1-10000	F. C. Donn	Plotted and drawn.
Saco Bay, Maine, Spurwink River to Scarboro River	1-10000	W. C. Willenbucher	Do.
Saco River, Maine, approaches to	1-10000	......do	Do.
George's Shoal, Massachusetts	2 ft-1 mile	.... do	Do.
Long Island Sound, Negro Heads to Southwest Ledge	1-10000	......do	Do.
Long Island Sound, Southwest Ledge to Welch's Point	1-10000	......do	Do.
New York Bar and entrance	1-10000	E. Willenbucher	Do.
New York Lower Bay, Sandy Hook to Coney Island	1-10000	......do	Do.
New York Lower Bay, west of main channel	1-20000	......do	Do.
Gravesend Bay and the Narrows, New York	1-10000	......do	Do.
New York Upper Bay, including Kill van Kull	1-10000	W. C. Willenbucher	Do.
New York Upper Bay and East River to Suspension Bridge	1-5000	......do	Do.
East River, Suspension Bridge to Blackwell's Island	1-5000	......do	Do.
East River, channels on both sides of Blackwell's Island	1-5000	.....do	Do.
Hudson River, Battery to Fourteenth street	1-5000	.....do	Do.
Hudson River, Fourteenth street to Eighty-eighth street	1-5000	.... do	Do.

HYDROGRAPHIC DIVISION.

Original hydrographic sheets, plotted, verified, and inked, &c.—Continued.

Title of sheet.	Scale.	Draughtsman.	Remarks.
ATLANTIC COAST—continued.			
Hudson River, Eighty-eighth street to One hundred and forty-first street.	1-5000	W. C. Willenbucher	Plotted and drawn.
Off Cape May Point	1-10000	F. C. Donn	Do.
Delaware Bay, east side, north of Cape May	1-20000	E. Willenbucher	Do.
Delaware Bay, Maurice River Cove, eastern part	1-20000	F. C. Donn	Do.
Delaware Bay, Maurice River Cove, western part	1-20000	......do	Do.
Delaware Bay, west side, Mispillion Creek to Murderkill Creek	1-20000	E. Willenbucher	Do.
Charleston Bar, South Carolina	1-20000	W. C. Willenbucher	Do.
Wadmelaw and Stono Rivers, South Carolina	1-20000	E. Willenbucher	Do.
Saint John's River, Racey Point to San Mateo, Fla	1-20000	......do	Do.
Strait of Florida and Northwest Providence Channel	1-200000	......do	Do.
Strait of Florida, latitude 27° 20′ to latitude 28° 20′	1-200000	......do	Do.
Wacassassa Bay, Florida	1-20000	......do	Replotted and drawn.
Dredged Channel, Mobile Bay, upper part	1-10000	......do	Protracted, plotted, and drawn.
Dredged Channel, Mobile Bay, lower part	1-10000	......do	Do.
Horn Island Pass, Mississippi	1-20000	W. C. Willenbucher	Do.
Off Chandeleur Islands, Louisiana	1-80000	......do	Plotted and drawn.
Mermentau River, Louisiana	1-20000	......do	Do.
Calcasieu Pass, Louisiana	1-20000	......do	Do.
Entrance to Sabine Pass, Louisiana and Texas	1-20000	......do	Do.
Sabine Pass and Lake, Louisiana and Texas	1-20000	......do	Do.
Off coast of Louisiana	1-80,000	F. C. Donn	Do.
PACIFIC COAST.			
San Francisco Bar, California	1-20000	F. C. Donn	Verified, inked, and finished.
Brushy Point to Ussal Rock, California	1-20000	......do	Do.
Ussal Rock to White Rock, California	1-20000	......do	Do.
Humboldt Bay, California	1-20000	......do	Do.
Fuca Strait, Washington Territory	1-80000	......do	Do.
Hood's Canal and Doboy Bay, Washington Territory	1-20000	......do	Do.
Upper Hood's Canal, Washington Territory	1-20000	......do	Do.
Dixon Entrance and Clarence Strait to Moira Sound, Alaska	1-80000	E. Willenbucher	Revised and corrected.
Clarence Strait, Moira Sound to Union Bay, Alaska	1-80000	......do	Do.
Niblack Anchorage, Moira Sound, Alaska	1-10000	......do	Do.
Chasina Anchorage, Alaska	1-5000	......do	Do.
Vallemar Bay and entrance to Tongass Narrows, Alaska	1-20000	......do	Do.
Naha Bay and adjacent waters, Alaska	1-20000	......do	Do.
Twelve-Mile Arm, Alaska	1-40000	......do	Do.
Karta Bay, Alaska	1-5000	......do	Do.
Tolstoi Bay, Alaska	1-20000	......do	Do.
Union Bay, Alaska	1-20000	......do	Do.
Vicinity of Port Wrangell, Alaska	1-5000	W. C. Willenbucher	Protracted and drawn.
Additional hydrography plotted on thirty-two original sheets	Various	......do	Do.

Synopsis from the records of the hydrographic sheets plotted, &c., during the fiscal year ending June 30, 1886.

Draughtsman.	Sheets.	Volumes.	Angles.	Soundings.	Miles.	Deep-sea soundings.
E. Willenbucher	23	174	41,466	315,223	6,556	358
W. C. Willenbucher	20	103	24,614	128,009	2,349	....
F. C. Donn	12	80	27,305	152,227	5,152	....
Total	55	357	93,385	595,459	14,057	358

Verification, revision, and correction of reduced drawings of hydrography for the fiscal year ending June 30, 1886.

Catalogue number of chart.	Title of chart.	Scale.	Draughtsman.
8*a*	Approaches to New York	1-400000	E. Willenbucher.
102	Seal Islands to Petit Menan, western part	1-80000	W. C. Willenbucher.
114	Long Island Sound, easthern part, new issue	1-80000	E. Willenbucher.
124	Delaware Bay Entrance, new issue	1-80000	Do.
150	Cape Fear River and approaches	1-80000	Do.
164	Jupiter Inlet to Hillsboro Inlet	1-80000	Do.
165	Hillsboro Inlet to Fowey Rocks	1-80000	Do.
454	Saint John's River, entrance to Brown's Creek	1-25000	Do.
455	Saint John's River, Brown's Creek to Jacksonville	1-25000	Do.
455*d*	Saint John's River, Racey's Point to San Mateo	1-40000	Do.
480	Cedar Keys, new issue	1-50000	Do.
643	Gray's Harbor, Washington Territory	1-40000	Do.
654	Washington Sound and approaches	1-200000	Do.
701	Northwest Coast of America, No. 1	1-200000	Do.
709	Clarence Strait, Southeast Alaska	1-200000	Do.

Charts for which reduced drawings of hydrography were made during the fiscal year ending June 30, 1886.

Catalogue number of chart.	Localities affected.	Scale.	Draughtsman.
108	Merrimac River Entrance, Massachusetts	1-80000	E. Willenbucher.
111	Monomoy Passage, Nantucket Harbor, Massachusetts	1-80000	W. C. Willenbucher.
113	Providence Harbor, Rhode Island	1-80000	Do.
115	Long Island Sound, middle part, Connecticut	1-80000	Do.
124	Off Cape May, New Jersey	1-80000	Do.
158	Saint Mary's River Entrance, Florida	1-80000	Do.
186	Pensacola Entrance, Florida	1-80000	Do.
188	Mobile Bay Dredged Channel, Alabama	1-80000	E. Willenbucher.
352	Providence Harbor, Rhode Island	1-40000	W. C. Willenbucher.
353	Providence Harbor, Rhode Island	1-10000	Do.
425	Cape Fear River Bar, North Carolina	1-30000	Do.
431	Charleston Bar, South Carolina	1-30000	Do.
490	Pensacola Entrance, Florida	1-30000	Do.
490*a*	Pensacola Entrance, Florida	1-20000	Do.
520	Galveston Entrance, Texas	1-40000	Do.
637	Koos Bay Entrance, Oregon	1-20000	Do.

Miscellaneous draughting done during the fiscal year ending June 30, 1886.

Description.	Draughtsman.
Plotting 358 deep-sea soundings by latitude and longitude	E. Willenbucher.
Copying current curves, Gulf Stream, coast of Florida	F. C. Donn.
Tracing of same for photolithography	Do.
Tracing of two hydrographic sheets of dredged channel, Mobile Bay	E. Willenbucher.
Correcting curves and adding bottoms on charts, Catalogue Nos. 13 and 14	Do.
Tracing of corrected △ scheme, Southeast Alaska	Do.
Project for publishing Clarence Strait, Alaska, 1-200000	Do.
Project for publishing harbors in Clarence Strait, Alaska	Do.
Project for publishing Tongass Narrows, Alaska	Do.
Preparing proofs showing old and new surveys between Capes May and Hatteras	Do.
Introducing changes (from resurvey) to chart 115	W. C. Willenbucher.
Correction of numerous charts for files, Engraving Division and Chart-Room	Do.
Plotting Time-Ball Station on charts affected	Do.
Thirty-six tracings for special examination by hydrographic parties	Do.
One tracing for special examination by hydrographic party	F. C. Donn.
Two tracings for Light-House Board	W. C. Willenbucher.
Bringing up progress sketches, furnishing statistics and reports	Do.

Appendix No. 6.—1886.

THE SOLAR (ANNULAR) ECLIPSE OF MARCH 5, 1886—TIMES OF OBSERVATION AT SAN FRANCISCO, CAL.

Reported by GEORGE DAVIDSON, Assistant.

U. S. Coast and Geodetic Survey Suboffice,
San Francisco, Cal., April 16, 1886.

Sir: In my monthly report I mentioned that some of the Assistants here had observed the Solar Eclipse of March 5, 1886.

I herewith transmit a tabulated statement of the observations, drawn up by Mr. Hill.

The observations which I made were with my equatorial of 6.4 inches; the observations by my colleagues were made with reconnoitering telescopes having small apertures and low powers.

Very respectfully,

GEORGE DAVIDSON,
Assistant.

F. M. Thorn, Esq.,
Superintendent Coast and Geodetic Survey.

Observations made at the Coast and Geodetic Survey Station, Lafayette Park, San Francisco, Cal., and at the Davidson Observatory.

Lafayette Park Station (center of transit): Latitude, 37° 47′ 25″.1 N.; longitude, 122° 25′ 40″.7 W. of Gr.

Observations of I Contact.

[Predicted time $2^h\ 22^m\ 43^s$.]

Observer.	Telescope.		Chronometer.	Time as recorded.	Correction to chronometer.	True time observed.		Remarks, &c.
						Local.		
	Aperture.	Power.				Mean time.	Sidereal time.	
	Inches.			*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	
D.	6.5	170	Sid. 3,479	1 16 10.0	+0 0 48.54	2 22 37.1	1 16 58.5	Clark equatorial; Herschel solar eye-piece; probably 1 second late. ±1.0 second.
L.	2.5	40	Sid. 211	2 24 32.5	−1 07 13.3	2 22 57.7	1 17 19.2	
M.	2	80	M. T. 231	2 34 23.0	−0 11 28.3	2 22 54.7	1 17 16.2	Probably 3 seconds late.
W.	2.5	40	M. T. 229	9 43 37.5	−7 20 40.7	2 22 56.8	1 17 18.3	
H.	3	105	M. T. 1,705	2 28 07.5	−0 05 25.0	2 22 42.5	1 17 04.0	Not very sharp, but fairly good.

Observations of II Contact.

[Predicted time $4^h\ 35^m\ 38^s$.]

Observer.	Aperture.	Power.	Chronometer.	Time as recorded.	Correction to chronometer.	Mean time.	Sidereal time.	Remarks, &c.
				h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	
D.	6.5	170	Sid. 3,479	3 29 32.3	+0 0 48.7	4 35 37.7	3 30 21.0	Good observation; within ½ second
L.	2.5	40	Sid. 211	4 37 38.0	−1 07 12.9	4 35 41.7	3 30 25.1	
M.	3	105	M. T. 231	4 47 10.0	−0 11 28.2	4 35 41.8	3 30 25.1	Good.
W.	2.5	40	M. T. 229	11 56 19.5	−7 20 40.8	4 35 38.7	3 30 22.0	
H.	3	105	M. T. 1,705	4 41 05.8	−0 05 25.4	4 35 40.4	3 30 23.7	Very good, don't think it possible 1s.5 out.

Observers: D, George Davidson; L, James S. Lawson; M, Fremont Morse; W, P. A. Welker; H, Charles B. Hill.

APPENDIX No. 7—1886.

AN EXAMINATION OF SOME OF THE EARLY VOYAGES OF DISCOVERY AND EXPLORATION ON THE NORTHWEST COAST OF AMERICA, FROM 1539 TO 1603.

By Prof. GEORGE DAVIDSON, A. M., Ph.D.,
Assistant U. S. Coast and Geodetic Survey.

INTRODUCTION.

During my work on the Pacific coast of the United States since the spring of 1850 I became deeply interested in the discoveries and explorations of the early Spanish navigators who had followed the coast from Cape San Lucas to Alaska. Part of my duty consisted in the determination of the latitude and longitude of the headlands, islands, rocks, harbors, rivers, &c., and in the geographical reconnaissance of the shores from the Mexican boundary to the forty-ninth parallel. While in command of the surveying brig R. H. Fauntleroy, I entered (in addition to my regular duties) upon the self-imposed task of writing a Coast Pilot for California, Oregon, and Washington Territory, and I have nearly completed the fourth edition of that work. Very naturally, my early interest in the old explorations became intensified, and I made many special examinations of the narratives and their application to supposed localities. I think I have been able to reconcile many of the discrepancies of the old Spanish, English, American, and French navigators. Their inaccuracies arose principally from "constant" errors of their instruments, ignorance of the coast currents, errors of judgment in estimating distances, &c. Among the Spanish discoverers, the meagerness of detailed descriptions, a failure to seize the salient points for the determining of their positions, the want of minute accuracy in most of their plans—sometimes giving weight to general features and sometimes to details without distinction—and a leaning to exaggerate certain discoveries and to completely overlook others, have much involved the locating of many of their landfalls, headlands, mountains, and streams. The minuteness of record in Cook and Vancouver, of comparatively recent date, has enabled me to follow their tracks day by day and to correct their positions by personal knowledge of the localities described; but whilst giving these great men the fullest credit for surveys unparalleled before or since (when all the attendant circumstances are considered), I cannot withhold my admiration for the indomitable courage and perseverance of the old Spanish navigators, who, in small, ill-conditioned, and ill-supplied vessels, with crews nearly destroyed by scurvy, fought their way to the wildest parts of the Alaskan coast almost regardless of season. "There were giants in the earth in those days."

The records of such of these voyages as are published are too short to be of much more value than isolated statements of what was done; and the inaccuracy of the observations for the determination of the geographical positions has led many to judge that all were touched with the spirit of Maldonado, de Fonte, and de Fuca. But with the present knowledge of our coast it is possible to locate Ulloa; to track Cabrillo and Ferrelo in their discoveries in mid-winter; to place Drake under Cape Ferrelo and Point Reyes, and to fix with certainty the most of Vizcaino's positions. Later than 1603 I have not undertaken identification in this paper, except to incidentally mention Father Taraval's visit to Point Eugenio, and his landing upon Natividad and Cerros

Islands. I was particularly interested in the voyages of Cabrillo and Ferrelo, and I have endeavored to put myself in their places; and understanding the seasons and the difficulties they encountered, I have tried to follow them day by day in their exciting discoveries.

I have based my narrative of Cabrillo upon the condensed and unsatisfying chapters in Herrera (B), and have corrected several mistakes and deciphered one or two obscure passages.

Of the narrative supposed to embrace the whole voyage of Cabrillo and Ferrelo, I have freely used the translation made by Mr. Richard Stuart Evans as printed with introductory remarks by Mr. H. W. Henshaw (H), but in critical passages where important issues were involved I have examined the original (C) and made my own translations.

Of the voyage of Ulloa, I have had recourse to the short narrative given in Burney and translated from (A).

Of the voyage by Drake, I have collated from the "English Hero" (D), and the "World Encompassed" (E), with reference to the Portus Novæ Albionis in the margin of Hondius' map; and to this map I have reduced the Coast Survey chart of the vicinity of Drake's Bay to correspond in scale and in orientation, whereby I have identified his bay.

In the voyage of Vizcaìno I first trusted to the English translation of Venegas' narrative, but I found it so uncertain in critical positions that I had recourse to the original (F); and I have used Vizcaìno's chart of the coast exhibited in Burney, Part II of his series of volumes of Voyages and Discoveries (G).

For details of some of the points and anchorages south of Todos Santos Bay I have used the Coast Survey charts of 1874 and the descriptions of the "West Coast of Mexico, from the Northern Boundary," published by the Hydrographic Bureau of the United States Navy (I).

To preserve accuracy and consistency of description on the coast north of Mexico, I have referred to the manuscript of the fourth edition of the "Coast Pilot of California, Oregon, and Washington" (J), and constantly to the charts of the United States Coast and Geodetic Survey.

The full titles of these authorities are appended to this introduction with the reference letters.

In order to present as clearly as practicable the descriptions of localities by the different navigators, I have drawn them up in three parallel columns, preserving in the case of Cabrillo and Ferrelo the whole of their narratives. My notes and remarks have been placed in another column. At the close I have added a condensed tabular statement of the names and positions of the seventy places mentioned by Cabrillo and Ferrelo and which I have identified. In the narratives I have occasionally added a note or condensed statement in brackets [ ].

In regard to the name "California," I extract the following note from the California Coast Pilot already referred to:

"The name California is first found in the worthless romance 'Las Sergas of Esplandian, the son of Amadis of Gaul, written by Garcia Ardonez de Montalvo, the translator of the Amadis. It was first printed in 1510, with editions in 1519, 1521, 1525, 1526 (two), 1575, 1587, and the recent reprint of 1857.*

"The name appears in several passages, of which the following are given:

"'Know that, on the right hand of the Indies, very near to the Terrestrial Paradise, there is an island called California, which was peopled with black women, without any men among them, because they were accustomed to live after the fashion of Amazons.

"'In this island called California are many Griffins, on account of the great savageness of the country and the immense quantity of wild game found there.

"'Now in the time that those great men of the Pagans sailed (against Constantinople) with those great fleets of which I have told you, there reigned in this land of California a Queen, large of body, very beautiful, in the prime of her years, &c.

"'The name California next occurs in the memoirs of the Conquistador, Bernal Diaz del Castillo, who served with Cortes in the conquest of Mexico. He writes that "Cortes again set sail from Santa Cruz and discovered the coast of California." Here Cortes remained for some time, disheartened at the want of success of his various expeditions. The viceroy, Mendoza, dispatched

* The full title of the book is "Las Sergas del Mey Esforxado Cabalero Esplandian hijo del excelente re Amadis de Gaula."

a vessel under the command of Ulloa with letters to Cortes. "Ulloa had a most favorable voyage and soon arrived in the harbor where Cortes lay at anchor. The letters of his wife and those of his children, and of the viceroy, had so much effect upon him that he gave the command of his vessel to Ulloa, embarked for Acapulco, and when he had arrived there hastened to Quauhuahuac, where his wife resided. * * * Shortly after, also, the troops arrived which had been left behind in California."

"'After a few months' repose Cortes sent out a more considerable expedition, under command of Ulloa. "This armament left the harbor de la Navidad in the month of June of one thousand five hundred and thirty, and so many years—I forget the exact year."

"The California referred to above is the peninsula of that name, generally known as Lower California, and the date 1535. They are the only times in which Diaz uses the name. (Cap. C. C.)

"In 1539 Francisco de Ulloa determined Lower California to be a peninsula. This fact appears to have been subsequently forgotten, for it was called La Isla de Las Carolinas, in honor of Charles II of Spain, and late in the last century the charts continued to delineate it as a great island parallel to the continental coast.

"The name California was gradually used to designate the region from the Gulf of California to the mythical "Straits of Anian," (which were very probably Bering Straits).

"The country was called New Albion by Sir Francis Drake in 1579.

"In recent times the region north of San Diego was called Alta California, and that to the south Baja California.'"

I cheerfully express my thanks to John T. Doyle, esq., and to H. H. Bancroft, esq., of San Francisco, for courtesies extended in my examination of some of the older authorities; and to E. J. Molera, esq., for assistance in rendering several old Spanish idiomatic phrases.

The principal works which I have consulted are—

(A) *Ulloa.*—There is no Spanish record or book of his explorations. The Italian account is in the third volume of the Navigations and Voyages of Gio. Battista Ramusio, pp. 339–354, published in Venice in 1865. It is published in English, in Hakluyt, Voyages III, pp. 397–424. The title is:

Ulloa. Relatione della Scoprimento che nel nome di Dio va à far l'armata dell' illustrissimo Fernando Cortese, Marchese di Valle con tri Naui, chiamata l'una Santa Agata, di Grandezza di dugento quaranta botto, l'altra, la Trinita, di grandezza di settanta e la terza San Tomaso, di quaráta, dellaquale armata su Capitano il molto Magnifico Caualiero Francesco di VLLOA habitator della città di Merida.

(B) *Cabrillo.*—Historia General de los Hechos de los Castellanos en las Islas y Tierra Firme del Mar Oceano, Escrita por Antonio de Herrera Coronista Mayor de Su Magestad de las Indias y Coronista de Castilla y Leon Decada Setima al Rey Nuestro Señor En Madrid en la Officina Real de Nicolas Rodriguez Franco 1730. Con Privilegio de Su Majestad.

Libro Quinto Cap. III. Del viaje que hicieron dos Navios, que embiò Don Antonio de Mendoça à descubrir la Costa de la Mar del Sur, desde Nueva-España. Cap. IV. Que prosigue el descubrimiento de los dos Navios de Don Antonio de Mendoça por la Mar del Sùd.

(C) *Ferrelo.*—Collecion de varios documentos Para la Historia de la Florida y tierras adyacentes. Largas en fazañas é cortos en descrebillas. Tomo I. En la casa de Trübner y Compañia. Núm. 60, Paternoster Row, Londres. (Se han tirado 500 Ejamplases por José Rodriguez, Madrid, Año de 1857, p. 173. Mar del Sur. 1542. Relacion, ó diario, de la Navegacion que hizo Juan Rodriguez Cabrillo con dos Navios, al descubrimiento del paso del Mar del Sur al Nortes desde 27 de Junio de 1542 que Salió del puerto de Navidad, hasta 14 de Abril del Siguiente año que se restituyó á él, naviendo llegado hasta el altura de 44 grados, con la descripcion de la Costa, puertos, ensanadas, é islas que reconoció y sus distancias, en la extension de toda aquella costa.

(D) *Drake.*—The English Hero: or, Sir Francis Drake revived. Being a full account of the dangerous Voyages, admirable Adventures, notable Discoveries, and magnanimous Athievements, of that valiant and renowned Commander. I. His Voyages in 1572, to Nombre de Dios in the West Indies, where they saw a Pile of silver Bars nearly 70 Feet long, 10 Feet broad, and 12 Feet high. II. His encompassing the whole World in 1577, which he performed in two Years, and ten Months, gaining a vast quantity of Gold and Silver. III. His voyage into America in 1585, and taking the towns of St. Iago, St. Domingo, Carthagena, and St. Augustine. Also his worthy

actions when Vice Admiral of England in the Spanish Invasion, 1588. IV. His last voyage in those Countries, in 1595, with the manner of his Death and Burial. Recommended to the Imitation of all heroic Spirits. Enlarged and reduced into Chapters with Contents. By R. B. The twelfth Edition. Dublin: Printed for G. Golding at the King's Head in High-street, 1739.

(E) *Drake.*—The World Encompassed by Sir Francis Drake, Being his next voyage to that to Nombre de Dios. Collated with an Unpublished Manuscript of Francis Fletcher, Chaplain to the Expedition; with appendices illustrative of the same Voyage, and Introduction, by W. S. Vaux Esq. M. A., London: Printed for the Hakluyt Society, M.D.CCCLIV.

(F) *Venegas.*—Noticia de la California, y de su conquista temporal y espiritual hasta el tiempo presenti, sacada de la Historia Manuscrita, formada en Mexico año de 1739, por el Padre Miguel Veuegas, de la Compañia de Jesus: y de otras Noticias, y Relationes antiguas, y modernas: Anadida de Algunos mapas particulares; y uno general de la America Septentrional, Assia Oriental, y Mar del Sur intermedio, formados sobre las Memorias mas recientes, y exactas, que se publican justamente: dedicada al Rey Ntro. Señor por la Provincia de Nueva-Espana, de la Compañia de Jesus. Tomo Tercero. Con licencia En Madrid: En la Imprenta de la Viceda de Manual Fernandez, y del Supremo Consejo de la Inquisicion. Año de M.DCC.LVII.

(G) *Burney.*—A Chronological History of the Voyages and Discoveries in the South Sea or Pacific Ocean. Part I. Commencing with an account of the earliest discovery of that Sea by Europeans, and terminating with the Voyage of Sir Francis Drake, in 1579. Illustrated with Charts by James Burney, Captain in the Royal Navy, London: printed by Luke Hansand, near Lincoln's-Inn-Fields, and sold by C. and W. Nichol, Bookseller to His Majesty, Pall Mall; G. and J. Robinson, Paternoster Row; J. Robson, New Bond Street; Mem's Gate; and Cadell and Davis, in the Strand, 1803.

(H) *Engineer Department U. S. Army.*—Report upon United States Geographical Surveys west of the one hundredth meridian, in charge of First Lieutenant Geo. M. Wheeler, Corps of Engineers, U. S. Army, under the direction of Brig. General A. A. Humphreys, Chief of Engineers, U. S. Army. Published by authority of the Honorable Secretary of War, in accordance with acts of Congress of June 23d, 1874, and February 15th, 1875, in several volumes, accompanied by one topographical and one geological atlas. Vol. VII. Archæology, Washington: Government Printing Office, 1879. (Appendix to Part I, Vol. VII, pp. 292–314.)

(I) *No. 56 U. S. Hydrographic Office—Bureau of Navigation.* The West Coast of Mexico, from the Boundary Line between the United States and Mexico to Cape Corrientes, including the Gulf of California. Washington: Government Printing Office. 1880.

(J) *United States Coast and Geodetic Survey, F. M. Thorn, Superintendent.* Pacific Coast. Coast Pilot of California, Oregon, and Washington. Fourth edition: By George Davidson, Assistant. 1886. [Yet in manuscript, August, 1886.]

The work upon this investigation has been done at intervals, independently of the regular duties of the U. S. Coast and Geodetic Survey, and has therefore been a long time in hand.

SAN FRANCISCO, CAL., *August*, 1886.

GEORGE DAVIDSON.

DAVIDSON.

FERRELO.

Juan Rodriguez set sail from the Puerto de Navidad to discover the coast of New Spain on the 27th day of June, 1542.

He was delayed from the Puerto de Navidad to Cabo Corrientes a day and a night, forty leagues, with a southeast wind.

From Wednesday to the following Thursday they held their course along the coast thirty-five leagues.

Sunday, the second day of July, they had sight of California: they were delayed in crossing over, by the weather, which was not very favorable, almost four days; they anchored the following Monday, on the third of the same, off the Point of California, and were here two days, and from this place

The Port of Navidad is in latitude 19° 13′ N. and twenty miles west-northwest from the harbor of Mansanilla.

El Cabo de Corrientes, in 20½°, Cabrillo. Latitude 20° 25′: correction to Cabrillo, —0° 05′ if he observed the latitude, which I very much doubt.

Thirty leagues, by the charts.

La Bahia de Santa Cruz, Ulloa.

El Puerto de la Cruz, 24° and "more," Cabrillo.

El Puerto del Marques del Valle.

(The Emperor had given Cortes the title of Marques del Valle del Quaxaco in 1528.) This port is probably the cove under Cape Pulmo.

The Point of California "in 24° and more," is quite likely the present Cape Pulmo which is the easternmost land of the peninsula of Lower California, and placed in latitude 23° 23′, so that the correction to Cabrillo would be —0° 37′ "and more." Hence to Cape San Lucas following the coast line the distance is 44 geographical miles.

The cliffs at Cape Pulmo are 410 feet above the sea, and within a mile the hill rises to 850 feet with a low neck or valley behind it, so that from the northward or southward this hill presents a notable feature. Inside of this the mountains eight miles westwardly rise to 2,885 feet, while Miraflores of the Sierra la Victoria, 27 miles from the gulf shore, rises to 6,200 feet elevation: the former is visible at 62 miles distance, the latter at 91 miles.

On the south side of Cape Pulmo there is a nice cove three-quarters of a mile deep where anchorage may be had in ten fathoms within two hundred yards of the beach. Fresh water is found in the arroyo which opens on the cove.

This bay is probably the Puerto del Marques del Valle where one of Cortes ships put in during the expedition of 1534, and where Ximenes the Captain (who had mutinied as pilot) was killed. The bay of Santa Cruz was visited by Cortes himself in 1536. In 1596 El General Vizcaino, under orders of Don Gaspar de Zuniga Conde de Monte-Rey, visited the eastern shore of the southern end of the Peninsula of California and remained eight days at the Puerto de San Sebastian, but abandoned it for a more convenient place, and sailing further they came to the Puerto de la Paz. This Puerto de Santa Cruz may therefore be reasonably considered the same as that of the Marques del Valle.

CABRILLO.

Don Antonio de Mendoça took more interest in maritime matters, for notwithstanding the vessels he had sent to discover that part of the coast of New Spain, towards the South, had suffered a great deal, he sought, by every means, to know what there was further on; and for that purpose he ordered two vessels to be fitted out, and appointed for Captain of them Juan Rodriguez Cabrillo, a Portuguese, a person very conversant with the matters of the sea.

One of the vessels was named the San Salvador, which was the flagship, and the other La Victoria; there was for chief pilot Bartolomè Ferrer, and also for pilot Bartolomè Fernandez; and for masters Antonio Carrera, and S. Remo.

These vessels being quickly made ready, they sailed from the Puerto de Navidad, on the twenty-seventh of June, of the present year, [1542,] at noon, and arrived early in the morning at Cabo de Corrientes in twenty degrees and a half.

Friday, on the 30th, running along the coast, they found themselves in twenty and two degrees, and a third.

Sunday, on the second of July, they found themselves in twenty and four degrees and more, and recognized the Puerto del Marquez del Valle, which they called de la Cruz, which is the Coast of California.

ULLOA AND VIZCAÌNO.

VIZCAÌNO.

[Vizcaìno, with his three vessels and a long boat, left Puerto de la Navidad on the twenty-second of May 1602; continuing his course with adverse winds nearly to Cape Corrientes where he arrived on the twenty-sixth; and after a survey of that vicinity he proceeded along the Coast to Mazatlan, where he arrived June second.]

ULLOA.

"On the eighteenth of October, they reached the bay of *Santa Cruz*. October twenty ninth, [1539], Ulloa sailed with the Santa Agueda and the Trinidad, from the bay of *Santa Cruz*, to follow, as before, the trend of the coast: but being impeded by contrary winds, he had advanced on the tenth of November not more than fifty-four leagues from the bay of *Santa Cruz* towards the south and southwest."

VIZCAÌNO.

[From Wednesday to the following Thursday they held their course along the coast of New Spain thirty-five leagues.]

"Sunday, on the second day of July, they had sight of California: they were delayed in crossing over [the Gulf of California] by the weather, which was not very favorable, almost four days; they anchored the following Monday, on the third of the same month, off the Point of California, and were here two days."

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El Puerto de San Lucas, "They say it is in latitude 23°," Ferrelo:

La Bahia de San Bernabè, Vizcaino:

San Lucas Bay; latitude 22° 52′.

Correction to Ferrelo, — 0° 08′. Either Ferrelo obtained the latitude at second authority, or his instrument was badly deranged thereafter, as well as at Santa Cruz; I think the former.

It was in this harbor of San Lucas that the English navigator Cavendish, in 1587, captured, plundered, and burnt the Spanish galleon Santa Ana from the Philippines. This name suggests this bay as that where the Mexican astronomers observed the Transit of Venus in 1769, when the French expedition under Auteroche de la Chappe occupied a station at San Jose del Cabo, a few miles eastwardly, which I recovered in 1873.

San Lucas Bay affords good anchorage and shelter from the northwest and southwest winds, but it is open to the sea from the south to the east, rendering it exceedingly unsafe during the summer and autumn, or wet season, when the gales are very frequent and violent. The best anchorage is in six or seven fathoms of water, a quarter of a mile from the beach. Wood and water are obtained here.

Vizcaino gives a full description of the natives, the fresh-water lake, the fishes, and the productions of the land.

FERRELO.

they reached the Puerto de San Lucas the following Thursday, and took in water; they saw these days no Indians: they say [dizen] that this port is in twenty-three degrees, and from the point to the port it is clear and soundable, and the land is bare and rugged.

DAVIDSON.

La Punta de la Trinidad. Cabrillo; Ferrelo in 25°. This is undoubtedly

Cape Tosco, in latitude 24° 17′. Correction to Cabrillo and Ferrelo,—0° 43′.

From Cape San Lucas to Cape Tosco, a distance of 130 miles, or 43 leagues, there in no prominent point or indentation of the coast line, except immediately under the latter cape. The shore is marked by long lines of dreary sand dunes, except near Cape Falso and half way hence to Cape Tosco, where there is a "low, rocky point called the Point del Marques. A reef of rocks extends a short distance out from it, and on either side near the coast are low sandy bluffs."

"Vessels may anchor anywhere along this part of the coast in fine weather in from 8 to 10 fathoms, a mile or two from the beach. The soundings are regular, and there are no hidden dangers. The beach is generally steep, and the breakers close to it."

Immediately behind this point the land rises to "Las Mesas," or table-lands, of 600 feet elevation. To the southeastward stretches a great chain of mountains, reaching Cape San Lucas, and ranging from 4,000 to 6,200 feet elevation; and visible at a distance of ninety-one miles.

The point is laid down on the U. S. Coast Survey chart in latitude 23° 56′ north, and the indications are against any anchorage when the northwest winds are blowing; although Ulloa anchored eight or ten leagues to the southeast of Puerto Trinidad. Vizcaino met with strong currents from the northwest along this stretch of coast.

There must be some omission in Ferrelo's narrative wherein he gives the distance of five leagues from Cape San Lucas to Cape Tosco. The actual distance is 43 leagues along the coast. His estimates are so vague that

FERRELO.

They departed from the Puerto de San Lucas Thursday, the 6th, in the night, and the following Saturday, on the eighth of the said month, they cast anchor under the Punta de la Trinidad, which is in twenty-five degrees; it is from San Lucas five leagues;[1] it is a clean coast without any irregularity; within, on the land, appear high and bare and rugged ridges; they were at anchor here on account of contrary winds from west-northwest until the following Wednesday.

CABRILLO.

On the eighth day of the same month, they found themselves in twenty and five degrees, which is la Punta de la Trinidad.

ULLOA AND VIZCAÌNO.

ULLOA.

"The country near the southern cape of California was beautiful, and appeared to be well inhabited. The shore was bold, the least depth, as they sailed, being fifty-four fathoms.

The coast [bordering the Pacific Ocean] was soon found to take a northern direction, and their progress was opposed by a long continuance of northwest winds. The two ships were separated and rejoined twice within the first month after quitting Santa Cruz."

VIZCAÌNO.

"The squadron of Vizcaìno entering this bay under Cabo de San Lucas, on the feast of San Barnabas [June 11th], it was called after the name of that Saint. * * * In this bay the squadron lay some days to wait for the change of the moon, repair the ships, and take in wood and water. * * * (P. 38.) Three times the squadron sailed out of the bay, and were as often through the violence of the wind and the roughness of the sea, obliged to put back. They again set sail on the 5th of July, which was the fourth time (p. 46)."

ULLOA.

[On the first of December, they anchored near the coast, and boats went to procure water; in doing which, they were attacked by the natives. Captain Ulloa and some others were wounded, not dangerously,] "and Berecillo, their best mastiff dog, (they had two others) was wounded with three arrows, and would no more return to the charge."

[Near this watering place they found a bay or port, with three fathoms depth at the entrance, and deeper water within. No latitude is mentioned.]

VIZCAÌNO.

"And coming near the shore on the 8th of the month, facing some highlands, they were becalmed, that in a week they did not gain a single league; and on this account they gave that high land the name Sierra del Enfado, or Mount Tiresome (p. 47)."

[On his chart Vizcaìno simply says "This coast is free from dangers" half way to Cape Tosco, and hence to Tosco "low beaches." The chart has a weak point near the present Point del Marquis.]

DAVIDSON.

no supposition can fairly be made as to what he intended to say.

La Punta de la Trinidad, 25°, Cabrillo.
El Puerto de la Trinidad, 25°, Ferrelo.
La Bahìa de San Abad, Ulloa.
La Bahìa enganosa de Santa Marina, Vizcaìno (p. 51).
El Puerto del Marquès, ò de Santiago of Vizcaìno (p. 52).
La Bahìa de Santa Marina, Vizcaìno's chart.
Santa Marina Bay, in latitude 24° 20′.

Santa Margarita Island. It is twenty-two miles long, about five miles broad at the broadest place, and rises in barren peaks to 1,900 feet elevation.

El Puerto de San Pedro, 25½°, Ferrelo.
El Puerto de la Magdalena, Vizcaìno (p. 49).
La Bahìa ò Puerto de la Magdalena, Vizcaìno, pages 50, 52, and chart.
Magdalena Bay is in latitude 24° 32′; correction to Ferrelo —0° 58′.

This large and spacious bay with a fine entrance three miles wide, with very deep water and high headlands, is well protected by great mountain barriers from the Pacific Ocean winds.

The magnificent sheet of water is thirty-five miles long by twelve miles broad, but is divided by a narrow throat into Magdalena Bay proper on the north, and Almega Bay on the south; the latter again opening southward into Santa Marina Bay. The depth of water in the two main bays is over ten fathoms. From the northern part of Magdalena Bay there is connection with a long line of lagoons running for sixty miles northward, and lying just inside the coast sand dunes. These lagoons have several openings to the sea, through the dunes, and were formerly the resort of innumerable whales.

El Morro Redondo, Vizcaìno's chart.
Cape Redondo, in latitude 24° 32′.

The northern point of the entrance to Magdalena Bay is Entrada Point.

La Bahia de San Martin, Ferrelo.
La Bahìa de Santa Marta, Vizcaìno's chart.
Santa Maria Bay, latitude 24° 44′.

This bay is four leagues northwestward from the entrance to Magdalena Bay, and lies broad open to the southwestward. It is eight miles between the northwest and southeast points of the entrance, and it is four and a half miles deep towards the northeast. The soundings decrease regularly from twenty fathoms to three fathoms at the sandy beach, which is backed by sand dunes. There are no dangers except a line of rocks extending half a mile from Cape Lazaro, which forms the northwest point. Inside the bay, on the east side of Cape Lazaro, there is good anchorage in six fathoms of water over sandy bottom. The southeast point of entrance to the bay is Cape Corso. When Cabrillo had reached El Puerto de la Magdalena or Pequeña, in latitude 27° by his reckoning, he says "This puerto is forty leagues from the bay of San Martin;" this would put it approximately in his latitude of 25°; but he makes no mention of such a port in his narrative when he was sailing past that part of the coast; although he had just left Santa Marina Bay and

FERRELO

Wednesday, on the twelfth day of said month, they departed from this place. In Puerto de la Trinidad, an island forms the port which is here, and it is a good port, sheltered from the west-northwest winds; the port of the island is at the head of the island on the southeast side, and the port is clear and soundable; it has neither wood nor water; the island has ten leagues of length and two leagues of breadth; they anchored that night.

They departed the Thursday following, and passed the Puerto de San Pedro, which is in twenty-five and a half degrees; in this port there is no water nor wood; its direction is southeast; it has a good shelter from the west winds;

CABRILLO. ULLOA AND VIZCAÌNO.

ULLOA.

"Eight or ten leagues farther to the Northwest, they came to some inlets like passages between islands, into one of which they sailed, and found a good harbor entirely enclosed with land, which they named Bahìa de San Abad. The latitude is not given. In this port they took a supply of water, and at this part of the coast they had intercourse with the natives, who exchanged pearl shells and feathers for beads and other trinkets; but this traffic was conducted with much caution and distrust, and their separation was not friendly."

VIZCAÌNO.

"(P. 49.) Vizcaìno's flagship entered the oay on the 20tn of July, 1602, but her consort did not on account of the fogs. The next day some soldiers ascended the mountain and saw her consort sailing northward. The Capitana being thus alone on Santa Magdalena's day, the father Commissary and Father Tomas said mass ashore; and on account of this festival the bay was named La Bahìa, or Puerto de Magdalena; it is very spacious, with several safe coves and anchoring places; has two entrances, and through it a wide arm of the sea runs up into the country. * * * (P. 50.) The frigate subsequently entered the bay, joined the Capitana, and both left in company (p. 51)."

[Vizcaìno's chart gives his anchorage in the Bay, the soundings, and the eastern passage to Santa Marina Bay. He designates it as La Bahìa de la Magdalena; and the southern point of the entrance is named Morro Redondo.]

[About five miles beyond Magdalena Bay he discovered the entrance to what appeared a very dangerous bay, but it had been entered by the Almiranta and is named on the chart La Bahìa de Sta. Marta.]

DAVIDSON.

looked into the present Magdalena Bay. As there is no other port immediately north of Magdalena Bay, it is reasonable to assume that La Bahia de San Martin and Santa Maria Bay are the same ports.

La Punta de San Lazaro, Vizcaino's chart.

Cape San Lazaro, in latitude 24° 48′.

From Cape San Lazaro the coast line takes a decided change of direction from west-northwest to north (magnetic), and also changes from the high mountainous range from Cape Tosco to Cape San Lazaro, to one that is low, sandy, and only broken by the entrance to great lagoons that stretch sixty miles northward from Magdalena Bay.

It is very probable that the receding of this low shore caused Ferrelo to designate it the head of a large ensenada or gulf; or else that he saw the great lagoons from the mast-head; in either case they would head in about latitude 24° 50′ or 25° 00′.

La Bahia de San Christoval, Vizcaino. In this ensenada is the entrance to the Boca de San Domingo, in latitude 25° 21′. It is three-quarters of a mile wide, with a shoal extending a mile off the entrance. There is a depth of seven and a half feet of water upon it at high tide. The southern end of the lagoon heads in Magdalena Bay, and also stretches northward thirty miles. A very low country lies to the eastward of it.

El Puerto de la Magdalena, 27°, Cabrillo and Ferrelo.

Pequeña Bay, in latitude 26° 14′. Correction to Cabrillo and Ferrelo,— 0° 46′. The distance from Santa Maria Bay is only thirty leagues.

This is a bay formed by an indentation of the coast, one and a half miles to the northward. The rocky point on the west is composed of volcanic bluffs thirty feet high, with a hill eighty-five feet high. The country is low, with sand dunes and lagoons farther in shore.

Vessels find shelter from the northwesters by anchoring in six fathoms of water one mile northeastward from the point. There is a large estero behind the point, but in some seasons it has no opening to the sea.

Vizcaino has a line of soundings along the shore from Cape Lazaro nearly to Point Abreojos, ranging from thirty to fifteen fathoms of water. And he has two indentations corresponding very nearly in position to Pequeña Bay and the open roadstead under Point San Domingo. His chart says this is a "broken, ragged coast," and inland "mountainous." Both statements are true. The charts of 1874 named the point forming Pequeña Bay, San Domingo; but on the latest charts it has no name, and San Domingo is transferred to the point thirteen miles to the west-northwest.

La Punta de Santa Catalina, Ferrelo.

San Domingo Point, of the latest charts; it is in latitude 26° 19′, and thirteen miles west-northwest from Pequeña Bay.

FERRELO.

they continued sailing along the coast, which forms a large gulf, the head of which is in twenty-six degrees; the land is low and covered with sand dunes, the coast white and clear; they proceeded, sailing along the coast with fair winds

as far as twenty-seven degrees, and Wednesday, on the nineteenth of the said month, they landed at a port which they discovered, and going on shore they found a path used by Indians, and followed it the distance of an arquebuse shot, where they found a spring of water; the land is level within and bare and very dry; they gave it the name of Puerto de la Madaena; it is forty leagues from the Bay of San Martin to this port.

The following Thursday, on the twentieth of this month, they departed from this port and proceeded, sailing along the coast with contrary winds, and about six leagues from that place they found an anchorage behind

CABRILLO. ULLOA AND VIZCAÍNO.

[On Vizcaíno's chart he names the head which forms the northwest point of Santa Maria Bay, La Punta de San Lazaro.]

"The whole coast beyond this cape is level and pleasant; and has only a few mountains in the inland country."

"On the 30th of July, they had sight of a bay, which seemed to be formed there by the issue of a river. * * * (P. 52.) There were breakers at the entrance. * * * This place or gulf had been surveyed by the Almiranta. It was named the Bahia de San Christoval, * * * because it was surveyed on the anniversary of that saint.' (P. 53.)

[The chart designates it as a "low coast."]

Wednesday, on the nineteenth, they discovered a port which is of good protection, which they called La Magdalena, in twenty-seven degrees, and here they took in water.

DAVIDSON.

San Domingo Point is a remarkable perpendicular rocky cliff of dark color, rising one hundred and seventy-five feet above the sea. The cliffs extend for several miles east and west of the Point. A short reef stretches out from the Point in a southwesterly direction. Anchorage may be had to the eastward of the Point, under its lee, in five or six fathoms of water, half a mile from the shore, where a vessel will find some protection from the prevailing wind.

To the northwestward of this Point a long line of lagoons lies just inside the sand dunes. Behind the lagoons the land is low and sandy and then rises gently to low table-lands. The mountains are from twenty to thirty miles inland.

El Puerto de Santiago, 27½°, Ferrelo.
La Bahìa de las Ballenas, Vizcaìno.
Ballenas Bay, latitude 26° 45′.
San Ignacio Lagoon, under Abreójos Point, in latitude 26° 42′; correction to Ferrelo,—0° 45′. It is 76 miles from Pequeña Bay, and 54 miles from San Domingo Point.

The whole bight east and southeast of Abreójos Point, for fifty miles, is bordered by low sandy shores, behind which stretch immense lagoons, which were the former haunts of the humpback whale. The San Ignacio Lagoon, seventeen miles east-northeast from Abreójos Point, penetrates twenty miles northward and has a channel that admitted whaling vessels (1854). Between this lagoon and Abreójos Point there is another large lagoon not named. From Ignacio Bay to San Domingo Point there is the long line of narrow lagoons already mentioned. The early navigators may very readily have imagined an extensive and deep bay lying well to the eastward of Point Abreójos, and stretching eastward and northward from and forming part of the Puerto Santiago. The highlands for thirty or forty miles retreat inland behind the San Ignacio Lagoon or Puerto.

The open bay just inside Abreójos Point is named Ballenas Bay; it is sixteen miles broad, east and west, and seven miles deep, north and south. The depth of water in it ranges from twenty fathoms to three fathoms close under the beach. The Point affords good protection from the prevailing winds of summer. An anchorage is had in six to seven fathoms of water over sandy bottom. With strong winds a large swell rolls in, causing a heavy surf on the beach.

The Point itself is low and sandy, with a long narrow lagoon stretching to the west-northwest. There is a barren hill 277 feet high three miles inside the Point. On its southeast side there is a pond with brackish water in it during the dry season. A ridge running north-northwest from the Point rises to mountains in twenty miles.

La Punta de Santiago, Ferrelo.
Abreójos Point.
Habre Ojo (Rocks), "Keep your eye open", 27¼° and and "more," Ferrelo.
The Abreójos Rocks, latitude 26° 46′.
Correction to Ferrelo,—0° 44′ "and more.
Whale Rock.

These dangers lie three miles west-southwest from Abreójos Point, and are about two miles in extent. One of them, Whale Rock, is four feet above water; the rest

FERRELO.

a point, which they called Punta de Santa Catalina, and so they continued sailing along the coast,

and the Tuesday following, on the twenty-fifth of the said month of July, they discovered a large bay in twenty-seven and a half degrees; they made very little progress these days on account of the bad weather; they dropped anchor in this port and gave it the name of Puerto de Santiago; it is distant from Puerto de Madalena twenty-three leagues;

there are from Punta de Santiago for five leagues some very dangerous shoals and rocks, and they do not appear except when the sea breaks upon them; they are one league from the land, and in a little over twenty-seven and a half degrees; they are called Habre Ojo.

"And the same night [July 30th] (p. 53), they continued their voyage until they came to the Bahia de las Ballenas; when approaching it, "at a considerable distance they saw a large bay, * * * (p. 54), but on approaching, it was found to be as it were intercepted by shoals. * * This bay [Ensenada] had been surveyed by the Almiranta, who gave it the name of Bahia de Ballenas on account of the multitudes of that large fish they saw there." They could not land for two days. The country is quite populous and the Indians peaceable.

[Vizcaino's chart exhibits this great bight east of Abreójos Point, with a long barrier of sand through it as if guarding the lagoons behind it. In front of this barrier is the legend "Arrecifes."]

[Vizcaino's chart has the sunken rocks off the point named "Abreojos;" and he evidently anchored under the point as his anchor denotes.]

DAVIDSON.

are sunken. The distance around them and the danger just off the point is eight or nine miles.

La Bahía de San Hipolito, Vizcaíno's chart.

San Hipolito Bay, latitude 26° 58′.

This open bay is formed by the indentation of the coast line east of Point San Hipolito. The eastern shore runs north for three miles and then sweeps to the eastward and southeastward for ten miles. Good anchorage may be had under the lee of the Point in five to seven fathoms of water over a sandy bottom, at half a mile from the low shore.

San Hipolito Point is quite low, and composed of black rock with barren sand hills fifty to one hundred feet high, rising a short distance from it. There is a sandy shoal extending over a mile from the Point.

A remarkable table-shaped mountain, of 1,227 feet elevation, lies five and a half miles north (magnetic) from the Point. Behind this rise higher mountains, three thousand feet in elevation.

Sierra de los Siete Infantes, Vizcaíno.

These seven peaks are in the mountain range, lying between Abreójos Point and San Roque Island, and about fifteen miles inland. They are not recognized on any of the charts to date. The range reaches an elevation of 3,400 feet.

Punta y Puerto de Santa Ana, 28°, Ferrelo.

Asuncion Point, latitude 27° 07′. Correction to Ferrelo,—0° 53′.

It is forty-seven miles in a straight line from Abreójos Point.

It is a low, sharp, bluff Point, with a cone-shaped hillock about seventy-five feet high at its outer extremity, and moderately high hills a short distance inland.

Asuncion Island.

San Roque Island.

These are the islands discovered by Ulloa, but not then named; nor were they named by Cabrillo.

Las Islas de San Roque, Vizcaíno in the Almiranta.

La Isla de la Assumpcion, by the Capitana; this is the first or southern islet.

La Isla de San Roque, Vizcaíno.

They are both named on his chart, with an anchorage under each.

Asuncion Island lies a little more than three-quarters of a mile to the south-south east of Asuncion Point, and is placed in latitude 27° 06′. It is three-quarters of a mile long, and less than a quarter of a mile wide; of sandstone formation, and entirely barren; towards its southern end some hills reach an altitude of one hundred feet.

The Island of San Roque is a rugged rock, one mile long east and west, less than half a mile wide at its broadest part, and about forty feet above the sea. It lies in the middle of San Roque Bay, about two miles from the shore, and has dangers off its eastern extremity.

It is in latitude 27° 08½′, and is twenty-five miles from Point San Hipolito, and six miles from Asuncion Island.

FERRELO.

They proceeded sailing on the same course along the coast, as far as twenty-eight degrees, and there anchored under shelter of a point. Here are groves of trees which they had not seen from the Point of California; it is from this point[2] to Puerto de Santiago at the northwest point twenty-three leagues. There are high and broken ridges with some woodland. We gave it the name of Santa Ana;

It has an islet about a league from the land.

[Vizcaìno's chart locates a bay about half way between the Abreójos and Asuncion Island; he designates it as la Bahìa de San Hipolito (p. 56). They sailed up it, and came to an anchor; but some soldiers being sent ashore in search of wood and water, they found the country everywhere extremely barren, and therefore returned on board (p. 56).]

"Midway between the bay of Ballenas and the Islands of San Roque there is a high Sierra from which project seven high and distinct peaks in line, and which have been named de las Siete Infantes [the seven Infants] (p. 56).

ULLOA.

"Almost the whole month of December [1539] the winds blew from the northwest, in which direction the coast was found to continue. At times they advanced a little, but at other times they were driven back. The first of January [1540] they arrived in sight of two small islands near the mainland;

VIZCAÌNO.

[Vizcaìno in the Almiranta was separated from the Capitana and Fragata, and discovered the Islas de San Roque (p. 56–57). The Capitana coasting under the same shores reached the first island on the evening of the Assumpcion (August 5th) and gave it the name Isla de la Assumpcion; the other island was two leagues further on, to which he sailed, and under which he anchored.]

"The island is of middling size, the soil sandy and gravelly, and covered with sea gulls. In some of the coves there are infinite numbers of sea wolves."

This island was named Isla de San Roque (p. 59).

DAVIDSON.

El Puerto Fondo, Ferrelo.

Table Head Cove or San Pablo Bay, in latitude 27° 11′, and about ten miles from Asuncion Point. It is an open bay about one and a half miles deep, formed by an indentation in the face of Table Head between the points named San Roque and San Pablo. It is apparently free from all hidden dangers, and affords good anchorage in from ten to fifteen fathoms of water, at about three-quarters of a mile from the shore.

The great headland, embracing Asuncion Point, San Roque Point, and San Pablo Point, known on our charts as Table Head, has hills 560 to 800 feet elevation, rising directly from the water; and the mountains reach 1,800 feet in six miles inland, and 3,400 feet in fifteen miles. It is the commencement of a very high and mountainous coast line hence to Point San Eugenio.

They anchored in the open bight eight miles east of the Morro Hermoso, and now named the Bay of San Cristoval, but without any claim to being reckoned a bay, for it is twenty-three miles broad and only five miles deep.

El Puerto de San Pedro Vincula, in 28½°, "and a little more," Ferrelo.

El Puerto de San Bartolomè, Vizcaino.

Port San Bartolomè, in latitude 27° 39′; correction to Ferrelo,—0° 55′.

The distance from Table Head Cove is eleven and a half leagues in a direct line.

"Port San Bartolomè is the best harbor on the west coast of Lower California between San Diego and Magdalena Bays. It is nearly circular in its general form, and is about two and a half miles in diameter." "Vessels may anchor anywhere in the bay." "The soundings are very regular, and the bottom sand."

El Morro Hermoso, Vizcaino.

Morro Hermoso (The Beautiful Rock). It is in latitude 27° 30′, and lies twelve miles southeast of Port San Bartolomè and thirty-nine miles southeast from the island of Cerros.

The seaward face of the Morro Hermoso is a bold, rocky cliff rising abruptly from the sea to a hill 900 feet in height. Immediately behind it the mountain rises to 1,536 feet, with higher mountains a little further inland. "Beyond the high and extensive table-lands of Point San Pablo there is a remarkable range of peaks from 2,000 to 3,000 feet elevation, and of variegated colors, corresponding well with Vizcaino's description." Four miles east of the Morro Hermoso there is a peak 2,232 feet high, and only one mile from the shore.

Ulloa, Cabrillo, and Ferrelo do not mention the Morro Hermoso, although the last two were in the Bay of San Bartolomè.

Thirty-five miles broad off the coast, in this latitude, the deep plateau of the Pacific Ocean is reached at 2,355 fathoms.

Island discovered, but not named, by Ulloa.

La Isla de San Esteban, Ferrelo.

La Isla de la Natividad de Nuestra Señora, Vizcaino, in the Almiranta.

Afègua (or Bird Island), Indian name, Taraval, 1734.

FERRELO.

Thursday, on the twenty-seventh of the same month, they departed from said Puerto de Santa Ana, and dropped anchor about six leagues from that place in a port which they named Puerto Fondo, on account of the great depth which it had, as near the land it had thirty fathoms; it is clear; and they departed the following day from the said port, and turned back three times to the said port with contrary winds, and they were in the said port until the following Monday.

Monday, on the thirty-first of the same month, they departed from the aforesaid Puerto Fondo and anchored about eight leagues thence that night, and the next day they departed on their voyage.

Tuesday, on the first day of August, they left that [anchorage] place, and they proceeded about ten leagues, where they anchored in a port to which they gave the name of San Pedro Vincula; this port is in sight of the Isla de Zedros. This port is in twenty-eight and a half degrees, and more; the land is high and rugged and bare; from California to this place we have seen no Indian.

Wednesday, on the second of the said month, they departed from this port, and the wind was contrary, and they proceeded beating; they cast anchor under an island which is four leagues distant from the southeast side of the island of Zedros, and they named this island San

CABRILLO ULLOA AND VIZCAÌNO.

"The Capitana and Fragata, not being hindered by the winds as the Almiranta was (p. 61), sailed into a good port, which they named de San Bartolomè. It is three leagues before you reach the island of Cerros. * * * They found no water on shore, and the land was extremely dry and sterile. And they found on the beach a resin which did not have a good odor, and which some supposed to be amber, because there were great numbers of whales there. Whatever it was there was enough to load a ship. As this port was discovered on the day of the San Bartolomè Apostol, the twenty-fifth of August, it was so named; and that night they sailed (p. 62).

[The chart shows "a rugged coast, without trees." The bay is well indicated, and an anchorage laid down under the north shore, well inside.]

"(P. 60.) The Almiranta, prosecuting her voyage [northwestward from San Roque Island], came in sight of a very lofty mountain, at the base of which the sea broke, and which was twelve leagues from Cerros Island, which they could not reach. Here, to double the point which the mountain makes, the Almiranta was more than eight days beating against the northwest winds, which were very strong. Every time they tacked they were within a stone's throw of the mountain and the mainland. This mountain has not a single herb or green thing, but it presents an appearance as if painted, and variegated with different colors, like fancy tapes and ribbons of every hue, so that it is a wonderful sight (p. 61). * * * Finally the weather cleared up a little, the sea went down, and they doubled the cape.

When the Capitana and Fragata were in sight of La Sierra Pintada, they did not encounter the strong winds which baffled the Almiranta."

ULLOA.

"On Monday, the 5th of January, 1540, having advanced since the first of the month thirty-five leagues [from the Islands Asuncion and San Roque], they came to two other islands, one of them much larger than the other, lying at some distance from the coast of the mainland.

DAVIDSON.

Natividad Island, in latitude 27° 53', and its southern part is three leagues from Cerros Island.

Natividad Island is about three and three-quarters miles long, northwest and southeast, and from half a mile to a mile wide, being broadest at its southeastern end. It rises to 502 feet elevation; is hilly and barren, with mostly steep rocky shores surrounded by detached rocks and kelp. The passage between the island and Point Eugenio is nearly four miles wide.

On the southeastern end of the island there is a sand beach half a mile long, and vessels may anchor off this in ten fathoms of water among the kelp. But there are several dangers off this southern end of the island, such as Flat Rock on which the sea breaks continually.

La Isla de los Cedros (Ulloa).

La Isla de Zedros, Ferrelo; in 29°.

La Isla de Cerros, Vizcaino (p. 58 *et seq.*); and the same on his chart.

Amalgua (or Fog Island), Indian name; Taraval, 1734.

Cerros Island, latitude of the southernmost point, 28°02'.

Correction to Ferrelo,—0° 58'.

El Cabo de San Augustin, Vizcaino.

Cape San Augustin.

The change of name from Cedros to Cerros was quite natural, for Vizcaino says (p. 67), "Que la Isla de Cerros tendria de box treinta leguas, y en ella vieron grandes Pinares, y Cedros, en las Coronas, de los mas altos Cerros." (That the island of Cerros is about thirty leagues in circuit, and on it we saw great pines and cedars on the summits of the highest mountains.)

The island lies nearly north and south for twenty-one miles, with a broad base of nine miles at the southern end, and an average breadth of four miles. It is of volcanic origin, with numerous high peaks, the highest of which attains an elevation of 3,955 feet. In clear weather these peaks may be seen from a distance of sixty miles. They were probably seen by the explorers from the vicinity of Table Head.

The eastern side of the island is a succession of rocky ledges and ravines, with the land rising abruptly in sharp ridges and precipitous cliffs.

The northern part of the island is formed by broken bluffs, and outlying rocks. A sharp peak, 1,761 feet high, with a crest of cedars, rises just back of this point.

The western side has the same general character as the eastern, but with more outlying rocks. Many of the crests of the western slopes of the mountains sustain cedars sixty to seventy feet in height. The character of the southern shore is much like the eastern, but under both the sea is comparatively smooth, and anchorage may be had in seven to ten fathoms of water close under the shore. Vizcaino notes five such anchorages on his chart. On the southeast side of Cape San Augustin, which is 832 feet in height, lies South Bay with from four to ten fathoms of water. An indentation of two and a half miles forms this bay, where anchorage may be had in seven fathoms of water, close to the shore, and sheltered from the prevailing winds, but open to the southerly gales that occur during the early part of the winter. In

FERRELO.

Esteban. With the extremity [the northern shore] of the point of the mainland running east and west, the coast [to the southward] is northwest and southeast; it [the island] is a league from the mainland: from this point the mainland turns the coast line towards the northeast, and makes a great gulf, so that the land is not visible. Between the island and the mainland there is a good channel, and they had to pass close to the island, for there are rocks which extend in a reef from the point for a quarter of a league. There is much vegetation on the water, that grows from the bottom, and is matted beneath the surface. This island trends with San Pedro Vincula northwest and southeast; this island has three leagues in circuit. We were at this island with the wind contrary until the following Saturday, the fifth of the said month of August. It has a good port on the side towards the southeast. There is much fishing with a hook, and many birds are found.

They departed from the island of San Esteban Saturday, on the fifth day of August, and anchored at the Isla de Zedros, where they remained until Thursday, the tenth of the said month, taking in water and wood. They found no Indians, although they found some sign of them. The leeward point of this island on the south side is in twenty-nine degrees, and it has on this south side good ports and water and wood, and it is on this part bare, as it has only some small bushes. The island is large and high and bare, and runs almost east and west, and is on this side to the south twelve leagues in length.

[See page 184 for mention of the island on the return of the expedition.]

CABRILLO.

ULLOA AND VIZCAÌNO.

They were high, and on the top of each were many tall, slender trees."

VIZCAÌNO.

"And the Almiranta proceeded towards the Mountain, or Island of Cerros, passing between the mainland and a small island which they named the isla *de la Natividad de Nuestra Señora* (p. 61).

The Capitana and the tender sailed from Port Bartholomè on the 24th of August, in the night, and they did not see the island of Natividad, but passed close to it (p. 62).

And they named the small island la *Isla de la Natividad*, and it is wholly a desert, with only one sort of wild fennel (p. 68)."

ULLOA.

"The large island was twenty leagues in circuit, and was afterwards named Isla de los Cedros. * * * On the ninth of January they were obliged to run back for shelter under the Isla de Cedros, near the south part of which they anchored in thirty fathoms.

This side of the island was mountainous, and covered with burnt earth and ashes; * * * they did not see any appearance of vegetation. They landed, and by digging pits obtained water, in small quantity and of indifferent quality.

On the 14th, they anchored near the northern part of the island, which had a very different aspect from the opposite extremity, being well covered with trees, and inhabited.

The next day they anchored in thirty fathoms, near an Indian village on the same island, and Captain Ulloa went with two boats to search for water. * * *

[He had a conflict with the Indians, and his dog Berecillo was badly beaten.]

The canoes of these Indians were made of the trunks of the cedars, not hollowed, but merely fastened parallel and close to each other. Some of these trunks were twice the thickness of a man, and six yards in length. On the hills in the north part of the island, there were groves of these trees, for which reason the name Isla de los Cedros was given to the island."

VIZCAÌNO.

"At daybreak on the 25th of August, the Capitana and Fragata were close to the Island of Cerros which the Admiral thought was the mainland, and therefore he coasted to the westward; but it pleased our Lord, whom we serve, that for nine days they were unable to double a point which is part of the same island, and which he named el *Cabo de San Augustin*. Wearied by continual tacking the General determined to run close under the land, where he thought he would be sheltered from the northwest winds; and after he had anchored he sent for the Fragata, and in her the Cosmographer Geronymo Martin, to make a reconnaissance of the Island. And so he came to an anchor under the south part of the Island of Cerros [in South Bay], on the last day of August. * * * And the Fragata discovered the Almiranta this day and the fleet was reunìted (p. 65)."

this bay Vizcaino anchored on the 31st of August, 1602. Father Taraval, in 1734, went with the Indians from Point Eugenio to these islands on the same kind of catamaran or raft that is described by Ulloa. He named the group of islands embracing Natividad, Cerros and the Benitos, Los Dolores. Neither Ulloa, Vizcaino nor Cabrillo refer to the San Benito Islands.

The San Benito Islands form a group of barren and rocky islands sixteen miles west from Cerros Island. They cover an area of about six miles by two miles. The western or largest island of the group is about one and a quarter miles long and rises to six hundred and fifty feet elevation. There is anchorage in ten fathoms of water over sandy bottom, a little to the westward of its southeast point.

On the southwest part of the western islet a Japanese wreck was found by Captain Scammon in 1853. The keel and three or four strakes of the bottom remained. The nails, as well as the wood, proved it to be Japanese; and the indications were that it had been a long time in the water.

Bahia de San Xavier: by Father Taraval, 1734.

Sebastian Vizcaino Bay. This is the great gulf which has Cerros Island for its western limit, the north shore of the great range of the Sierra Pintada for its southern boundary, and the long, low, sandy shores of Scammon's Lagoon, Black Warrior Lagoon, &c., as far north as Playa Maria Bay, for its eastern shores.

In describing the landfall about Cerros Island this bay was referred to by Ferrelo as that "great gulf" [una ensenada grande que no paresce tierra], extending to the northeastward from Point Eugenio, but to which neither he nor Vizcaino gave any name. The latter has given no limit to its eastern shores; he saw them receding, but did not trace them. The frigate reported that she could not see the limit of this "great arm of the sea which penetrated the land far to the eastward" (pp. 67, 68).

To form this gulf the trend of the coast changes at Point Eugenio from northwest and southeast on the ocean side to east on the gulf side. From that point the shore is high and bold for thirty-three miles to the east; then becomes low and sandy and sweeps twenty-eight miles to the northeast, past the mouth of Scammon's Lagoon to Black Warrior Lagoon; then twenty-four miles northward past Lagoon Head; and finally changes again to high bold shores running northwest for nearly one hundred miles.

Scammon's Lagoon is the deepest part of this gulf. It is known to extend fifteen miles to the eastward towards the base of the Santa Clara Mountains. The entrance is in latitude 27° 54′, and bears E. by N. ¼ N., 41 miles from Point Eugenio.

Near the entrance to this and the Black Warrior Lagoon, the shore-line is backed by very high sand dunes, and drift logs have been found among these dunes two miles inland (1854). In Scammon's Lagoon Spanish cedar trunks of trees with branches were found by Scammon. They had drifted from the Mexican coast and islands.

La Punta de San Eugenio, Vizcaino's chart.

Sierra Pintada, Torquemada.

Point Eugenio, latitude 27° 50′.

This headland is not described by Cabrillo or Vizcaino, although it is a very remarkable landfall, and the southern boundary of the great Gulf of Sebastian Vizcaino. It is the western extremity of the mountainous penin-

CABRILLO. ULLOA AND VIZCAÌNO.

DAVIDSON.

sula, thirty-five miles long, and from three to twenty miles broad, which stretches from Table Head towards the northwest. Within seven miles of the Point the mountains are over 1,100 feet above the sea, and beyond the depression behind Port San Bartholomè they gradually rise to over 3,000 feet. The immediate shores are compact, bold, and forbidding. The prolongation of this peninsula is exhibited by the islands Natividad, Cerros, and San Benito.

El Puerto de Santa Clara, in 30° "scant," Ferrelo.

La Bahìa de San Hipolito, Vizcaìno, just under latitude 29° on his chart.

La Playa Maria Bay, latitude 28° 55′. The correction to Ferrelo is,—1° 05′ "scant," and the bay lies almost northeast (true), 17 leagues from the north end of Cerros Island.

Playa Maria Bay is formed by an east-northeast sweep of the shore-line for three miles from Maria Point, and then east-southeast for six miles to Black Point. It is about two and a half miles deep and six miles broad between the two points.

The shores are low, sandy, and barren. At the northeast angle of the bay there is a cone-shaped hill 256 feet high. Immediately behind this hillock, and to the northeastward, the latest charts place a lagoon, but the traders assert (1885) that there is no lake and no water here.

There is good anchorage in the northern part of the bay in six or seven fathoms of water, over sandy bottom, where vessels may lie protected from the prevailing summer winds.

For two or three miles back of the north shore the land is low and flat, and then it rises quickly to the great coast barrier which reaches nearly three thousand feet elevation.

I judge this to be Torquemada's San Hipolito, and not Santa Rosalia Bay twenty-three miles to the southeast where there is good anchorage and no fresh water, because Vizcaìno's Bay of San Cosme y San Damian, which lies four leagues to the northwest, has a fresh-water lake We lack detailed and accurate knowledge of this region, but it is probable the reported lagoon may have fresh water in very wet seasons.

San Hipolito had already been examined by the Almiranta when separated from the Capitan and Fragata.

Ensenada de San Cosme y San Damian, Vizcaìno.

Blanco Bay, in latitude 29° 04′.

Five miles from Maria Point the coast-line falls back one and a half miles and forms False Bay. Five leagues from Maria Point the shore recedes three miles to the northeastward, and forms Blanco Bay, which is a broad bight open to the southwest. Good anchorage may be found here protected from the prevailing coast winds. The shores are high and rocky, and the coast mountains reach 2,500 feet elevation in ten miles. There is said to be no fresh water here.

La Punta del Mal Abrijo, 30½°, Ferrelo.

Point Canoas, in latitude 29° 25′; correction to Ferrelo,—1° 05′. There is a possibility of its being Bluff Point, in latitude 29° 34′. Working back from San Geronimo Island, one of these points must be that which Cabrillo intended to designate as Mal Abrijo.

FERRELO.

They departed from the island of Zedros on Thursday, the tenth day of the said month of August, to pursue their voyage, and proceeded along the shores of the mainland, sailing to the north. They went this day about ten leagues, and the following Friday dropped anchor in a port which they called Puerto de Santa Clara; it is a good port. They landed and found four Indians, who fled. This port is thirty degrees scant; it trends with the island of Zedros, northeast and southwest, and this coast runs from the port towards the ensenada, north-northwest and south-southeast. The coast is clean and soundable; the land is bare and is not rugged. It has plains and valleys. They were in this port until Sunday, the thirteenth of the said month, on account of foul winds.

Sunday, the thirteenth of the said month, they departed from this port and went sailing along the coast with light winds, anchoring each night; and the following Tuesday they let go anchor under a point which forms a cove, which is in thirty and a half degrees; (4) it affords very little shelter; they called it Punta del Mal Abrijo.

VIZCAÌNO.

"And they sailed from this island [of Cerros] on the ninth of September [1602] in search of the Isla de Cenizas. But first the Armada sailed towards the mainland, which trended to the northwest: and on the eleventh the squadron made the coast, which on their approach they found to be level and pleasant, and they saw a bay, to which (p. 69) they gave the name of San Hipolito, and the ships came to anchor in it. * * * They found the country very fertile, and of a delightful appearance, and a broad beaten road, leading from the coast to the inland parts. They also found a large hut, covered with palm leaves, and capable of holding conveniently fifty people.

(P. 69) "Four leagues farther to the northwest of the ensenada of San Hipolito is another which they named La Bahia de San Cosme, y San Damian, which the Almiranta had surveyed, while she was in search of the Capitana. It is very well sheltered from the northwest winds, and near the shore on the mainland there is a famous fresh-water lake, and the country also is beautiful, fertile. and level."

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Point Canoas is a sharp perpendicular sand bluff 274 feet high, backed by hills from 700 to 1,200 elevation, and these again backed, at ten miles from the shore, with a range 2,100 feet above the sea. An anchorage partially protected from the coast winds is found under the lee of the point in good weather, in five to seven fathoms of water, over sandy bottom, about a mile form the shore.

From the point the shore-line runs ten miles eastward, of which the eastern six miles has a low shore with a broad plain behind it, according to the chart of 1873.

If he anchored deep in the bight between Point Canoas and Bluff Point, Cabrillo might have been abreast a deep arroyo laid down on the latest charts.

Vizcaino has an anchorage laid down just under 30°, but without name.

Cabo del Engaño, no latitude, Vizcaino. See page 184 for the Cabo del Engaño of Ulloa, Cabrillo, and Ferrelo.

Bluff Point; latitude 29° 34′.

A study of Vizcaino's narrative fully satisfies me that he applied this name to the headland which is fifteen or sixteen miles southeast of Point San Antonio.

Vizcaino had stormy weather here; his ships got separated; and he gives the particulars very clearly. He says the island of San Geronymo is about eight leagues to the west-northwest of Cape Engaño. It is just 25 miles.

Bluff Point is a bold sand point 100 feet high, and lies eighteen and three-quarter miles in a southeasterly direction from Point San Antonio. The sand bluffs on this part of the coast are backed by moderately high hills and in some portions by table-lands that rise from 1,000 to 2,000 feet in elevation. Of these mountains, Sombrero Peak, lying about two miles to the northeast of Bluff Point, is the most conspicuous, and reaches an elevation of 1,968 feet. The chart exhibits a "table land" ten miles in extent, to the northwest of Bluff Point, and about two thousand feet in height. It is only about five miles from the shore. This table-land is Las Mesas de San Cypriano of Vizcaino, in latitude 29° 42′.

La Bahia de San Francisco, Vizcaino. He gives no latitude. It is laid down upon his chart about three leagues to the southeast of the Isla de San Geronimo, and must be to the southeast of the Point Engaño or San Antonio, and to the northwest of Bluff Point. Abreast Las Mesas there is a great field of kelp stretching out to twenty-five fathoms of water, and it is probable that inside this kelp, under some slight indentation, they found anchorage, and gave it this name. A depth of twelve fathoms of water is found in this kelp four miles from the shore over a bottom of sand and rock. The slight indentation of the shore about five miles southeast of Point Engaño or San Antonio is in latitude 29° 43′, and under the northwest flank of Las Mesas. The latest charts do not give any anchorage at this place, nor has it any name.

Point San Antonio, latitude 29° 45′.

This is really the turning point of the coast-line, where it takes a new trend more to the northward. This is not the Cabo del Engaño of Cabrillo. It is not mentioned by Vizcaino in his narrative and his chart does not indicate it, but unusual prominence is given to the Island of

The Wednesday following they were sailing along the coast and had a heavy northwest wind, which was contrary, and they lay to at night without making any progress; and the following Thursday they held on with heavy rains and adverse winds and calms, so that they made no headway, and this following night they had much

(P. 70.) "As the Armada proceeded along the coast they saw many large fires and smokes made by the Indians. But the northwest wind blew so violently, and the air was so cold, that the squadron was obliged to run close in with the land, and on the sixteenth they were under some lofty black mountains, on the top of which were large plains. These they called Las Mesas de San Cypriano. To the leeward or southeast of this Sierra or range of mountains (p. 71) were some white cliffs; and on them great numbers of Indians. * * * However, the next day the weather became fair, with a gentle breeze, by which they recovered what they had lost during the storm, and arrived off the Mesas, where the land forms a point of the Cape. Here they were again overtaken by a most violent gale from the northwest, with thick weather, * * * and again lost sight of each other (p. 72). The reason for the usual violence of the wind at this Cape, called del Engaño, is that the air is there contracted betwixt the cape and the island of Ceniza, which lies about eight leagues distant along the mainland to the west-northwest of Cape Engaño (p. 73), and this island is divided in the middle, forming two steep, lofty, round mountains of equal height. * * * The Capitana alone * * * even ventured to double Cape Engaño.

"And having to the northwest of Las Mesas de San Cypriano and the Cabo de el Engaño (p. 73) found a good harbor, the General ordered the two ships to stand in for it. Accordingly, in the evening of San Francisco, which was the 3rd of October, they entered the bay, which they called La Bahia de San Francisco (p. 74). In a rancheria they found onions and goat's horns. The country is level and fruitful, and by the dung and other indications seems to have a great plenty of cattle and deer.

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San Geronimo. And I think it highly probable that it is not the Engaño of Ulloa, who may have reached this latitude, and seeing Point Baja beyond and a trifle farther to the westward, gave up the ceaseless struggle he had made against the northwest winds.

It is a bluff point, with a peak 570 feet high, close to the shore, and about one and a half miles southeast from the point.

About three miles southeast of the point there is the mouth of a very remarkable gorge, which extends more than a mile inland. Between this gorge and the high peak the San Rosario River enters the sea.

Ferrelo was under the coast between Bluff Point and Point San Antonio.

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wind from the west-northwest, and lay to for rest; and the following Friday they proceeded with fair winds and they found themselves to windward of the Point of Mal Abrijo six leagues; and so they held on [*their course*] until the following Saturday, on the nineteenth of the said month,

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La Isla de San Bernardo, 30½°, Ferrelo.

La Isla de San Gerónymo, Vizcaino.

San Gerónimo Island, latitude 29° 48′, correction to Ferrelo's latitude, —42′.

This islet lies eight leagues from Bluff Point, and thirteen leagues from Point Canoas. It is a league broad off Point San Antonio. Five miles to the south-southeast lies the dangerous Sacramento Reef. To the northward the trend of the shore is north-northwest, and to the southward southeast by east.

"It is a barren rock, covered in many places with a mixture of sand and guano; three-quarters of a mile long and less than a third of a mile broad; with rocky beaches and cliffs ten to twenty feet in height. Near the centre is a peak 172 feet high, and northward of this are two lower ones." * * * "There is anchorage to the eastward of the islet in about seven fathoms over sandy bottom, but an uncomfortable swell will usually be felt. A good landing place is found on a small shingle beach, in a slight indentation of the shore-line on the southeast side of the islet, at the base of the highest peak."

The present absence of wood may have resulted from fire spreading over the islet.

Torquemada is apparently confused about the Island of Cenizas and the Island of San Gerónimo, as if they were two distinct islands, and he even mentions the characteristics of each. The explanation is this: The Almiranta, after her separation from the fleet, searched for the Capitana by going as far back as Cerros Island, and then, not wishing to be again obstructed, made a long tack to seaward (p. 79), when she saw Guadalupe Island, which she named the Isla de Paxaros, and from this position she tacked inshore, making the landfall north of San Hilario Island (San Martin Island), which they saw and miscalled the Island of Cenizas (p. 89); thence she sailed in search of the Capitana, and when near the Bay of the Virgins she saw the Capitana and Fragata sailing out. This islet, as we shall soon see, is also double headed. Moreover, it is evident that the fleet had previous knowledge of some island described as Cenizas (cinders, lava), because on their passage to the northward they left Cerros Island to search for it. This knowledge they must have derived from the voyages of Ulloa and Cabrillo, and the description may possibly have referred to Natividad and Cerros Islands.

On Vizcaino's return voyage he passed the Bay of Todos Santos, and came in sight of the Island of San Hilario (San Martin Island) on the 3d of February (p. 122) And

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when they dropped anchor off a small island which is half a league from the mainland. It may be ten leagues from the Point of Mal Abrijo; it is in thirty and half degrees; it has a good anchorage and good shelter; they called it San Bernardo; it extends one league north and south. The coast of the mainland runs north-northwest and south-southeast, and is a clean coast. The land within is of very good appearance and level, and there are good valleys and some trees, and the rest is bare. They did not find these days a sign of Indians.

(P. 68.) "On the 9th of September, the squadron left the island of Cerros, to proceed to that of Cenizas. * * * The island of Ceniza which lies about eight leagues west-northwest from el Cabo de el Engaño [or Bluff Point] (p. 73). (P. 74.) The Fragata also reported that a little farther [beyond Bahia de San Francisco] they found a small island which they called San Geronymo; and the General ordered some of the sailors to go ashore and take a view of it. Here they saw prodigious numbers of birds, and much wood.

[On his chart it is named the Isla de San Geronimo.]

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"after passing the Bay of the Virgins on the 5th of this month, they made the island Cenizas, which, as we have already mentioned, had been surveyed by the Almiranta. Here the northwest winds increasing, the ships stood in for the Island of Cerros." This Island of Cenizas is certainly the San Geronymo of October 3d, 1602 (p. 74).

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El Cabo del Engaño, 30°, Ulloa.

El Cabo del Engaño, 31°, Cabrillo.

La Punta del Engaño, 31°, Ferrelo.

Point Baja, in latitude 29° 56′ (on a late chart, Punta Bajo). The correction to Cabrillo and Ferrelo is,—0° 64′.

It is eight and a half miles N. by W. ½ W. from San Geronimo Island, and NW. by N. ½ N., twelve and a half miles from Point San Antonio. Eastward of the point the shore retreats abruptly and forms Rosario Bay, in which safe anchorage may be had in five to six fathoms over sandy bottom, sheltered from the usual coast winds of summer. Punta Baja is a low sand cliff 30 feet high. Behind it the land rises to 300 and 500 feet in two miles, and to a mountain range of nearly 2,000 feet elevation within ten miles. The shores of Rosario Bay rise in sandy cliffs from 50 to 100 feet high. Off the point and the approaches great fields of kelp extend out into deep water

Sunday, the twentieth of the said month of August, they departed from the island of San Bernardo, and approached Punta del Engaño, which is seven leagues from this island, which point is in thirty-one degrees: the coast of the point towards the island trends north-northwest, south-southeast; on Punta del Engaño the land is not high, and appears in itself a good and level land; the ridges are bare: we saw no sign of Indians;

The coast from Punta Baja runs true north for twenty-four miles hence to Point San Quentin.

and so they continued sailing until the next Monday following the coast to the north and northeast; and about ten leagues from Punta del Engaño they discovered a good port, in which they anchored and took in water and wood: it is in thirty-one and a half degrees: it is a port suitable for making any kind of repairs for the ships, by placing the latter under the lee of the hills.

El Puerto de la Posesion, 31½°, Ferrelo.

La Bahia (de las Virgines), Vizcaino.

Port San Quentin in latitude 30° 24′; correction to Ferrelo,—1° 06′.

La Punta de las Virgines, Vizcaino's chart.

Cape San Quentin, latitude 30° 22′.

This cape is twenty-six and three-quarter miles NW. by N. from Punta Baja, and is the southern termination of a narrow peninsula eight miles in length, formed by a line of five remarkable hills lying north-northwest and south-southeast, and from 324 feet to 1,000 feet elevation. They were aptly named the Five Hummocks by Vancouver.

To the eastward of this peninsula there is low country, with great lagoons penetrating the land for several miles. The entrance to these lagoons is on the east side of the cape and two miles from its extremity. Inside of the entrance the port is small but affords perfectly secure anchorage and protection from all winds. No vessel drawing over twelve feet of water should attempt to enter the port without sending in a boat to sound the channel, which has two and a quarter fathoms of water at low tide.

The village of San Quentin lies five or six miles in a northeasterly direction from the anchorage, at the foot of a range of hills, and near some salt ponds.

Tebenkoff, in his hydrographic description of this part of the coast, says: "The only place where fresh water fit to drink is to be found, is the well, excavated by the Russians in 1805, situated upon the spit running from the right shore towards the Cape San Quentin. The soil is of sand and clay, impregnated with salt, and in

The following Tuesday the captain, Juan Rodriguez Cabrillo, went on shore and took possession of it in the name of His Majesty and of the most illustrious Señor Don Antonio de Mendoza, and gave it the name of Puerto de la Posesion. He found a lake which had three (³) [arms]; and they found some Indian fishermen, who immediately fled. They took one of them, and, giving him certain presents, they released him, and he went off. The land in the interior is high and rugged and has good valleys, and appears to be a good country, although it is bare. They were on shore here until Sunday, the twenty-seventh of said month, repairing the sails and obtaining a supply of water; and Thursday they saw certain smokes and went there with a boat and found about thirty fishermen, who were friendly, and they brought to the ship a boy and two Indian women, to whom they gave clothing and presents and let them go; from whom they could understand nothing by signs.

The following Friday, going to take in water, they found at the watering place certain Indians, who were friendly, and these showed them a pond of water and a salt pit which contained much, and they said by signs that they had not their habitation there, but in the interior, and that there were many people. This same day, in the evening, five Indians came to the shore, whom they brought to the ship, and they appeared intelligent Indians; and entering in the ship they took note of the Spaniards who were there and counted them, and made signs that they had seen other men like them, who had

CABRILLO.

On the twentieth of August they found themselves at Cabo del Engaño in thirty and one degrees.

ULLOA AND VIZCAÌNO

ULLOA.

"They sailed to the northward above twenty leagues beyond this island [of Cerros], and were then in thirty degrees of north latitude."

He "was driven back" by "the northwest winds, which continued fixed." * * * "Ulloa made many attempts to get to the north, but was always forced to return for shelter to the Isla de Cedros. The Santa Agueda, the larger vessel, being a heavy sailer, and in want of repairs, Captain Ulloa determined to send her back to New Spain, and to endeavor with the Trinidad only to proceed on the proposed discovery. * * * On the 5th of April the two vessels parted, the Sta. Agueda sailing for New Spain. [Incidentally this vessel notes sea weed growing in fifteen fathoms of water, &c.]

"Ulloa, in the Trinidad, endeavored in vain to get farther north. The utmost he reached was to a point of land which he named Cabo del Engaño [the Cape of Deception]. The winds blowing unceasingly from the northwest, and his provisions being nearly expended, he bent his course for New Spain, where he arrived after an absence of a year, which was employed in this expedition."

VIZCAÌNO.

"A little beyond this island (p.74) [of San Geronimo] there seemed to be a large bay or inlet (p. 75) with a very impetuous current both at the ebb and flood tides: and the General supposing there might be a large river at the bottom of it, stood in with both ships, in order, if it afforded a good harbor, to wait some days there for the Almiranta, which if not lost, must pass near the mouth of it. The tender stood in first, sounding all the way; but at the mouth of the estero found a bar with only three fathoms of water at low tide, so that the Capitana did not think it advisable to venture in; but the tender sailed over the bar, and found a good harbor. * * * They found near the coast a great number of naked Indians, fishing in canoes made of thick and pliable flags which grow in fresh water * * * And who showed them several wells of very good water, * * * which were in a thick copse of willows and osiers intermixed. * * * The Indians also intimated by signs that up in the country there were great numbers of people clothed, who had beards, and that they also had fire-arms. * * *

"The Capitana and Fragata having staid in this bay the time proposed, the General gave orders for putting to sea, in order to look out for the Almiranta; accordingly she got under sail on the 24th of October; but as they were standing out of the bay they saw the Almiranta, which gave them the greatest joy, not having seen her for twenty-eight days, and had now given her over for lost" (p. 78).

[On his chart Vizcaìno locates the Indian village; and makes two anchorages in the open bay.]

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places overgrown with a hard prickly plant, sheltering numbers of snakes: on the beach turtles and amphibians are constantly sunning themselves, as well as sea-elephants, sea-lions, and sometimes fur seals. There are very few birds."

From Port San Quentin the coast trends eastwardly for seven or eight miles and then turns to the southward, forming the open bay of San Quentin. The water is shoal for several miles off shore, and a long swell will usually be found rolling in, making it an uncomfortable anchorage. The north and east shore of the bay is a low sand beach, with the eastern hills rising to three hundred feet high a short distance inland, and these backed by a mountain range reaching from 1,500 to 4,000 feet.

In his narrative Vizcaino does not give any name to this "grande Bahia o Ensenada" (p. 74), but on page 80, when speaking of the Almiranta coming in sight, he refers to it as la Bahia de las Virgines.

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beards, and who brought dogs and cross-bows and swords. The Indians came smeared with a white bitumen on the thighs and body and arms, and they had the bitumen applied in the manner of slashes, so that they appeared like men in slashed doublets and hose; and they made signs that five days' journey thence were the Spaniards. And they made signs that there were many Indians, and that they had much maize and many parrots. They came covered with deer skins, and some had the deer skins dressed in the manner in which the Mexicans dress the skins which they carry in the cutters. This is an advanced and well-disposed people. They carry bows and arrows like those of New Spain, the arrows tipped with flints. The Captain gave them a letter, which they should carry to the Spaniards who they said were in the interior.

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La Isla de San Augustin, Ferrelo. He gives no latitude and no distance sailed from Cape San Quentin.

La Isla de Cenizas, Vizcaino, by the Almiranta (p. 80).

La Isla de San Hilario, Vizcaino, by the Capitana (p. 80).

San Martin Island, latitude 30° 29′.

On the chart of Vizcaino it is laid down just outside Cape San Quentin, but without name. On his return to New Spain, in February, 1603, he reached the wells of the Bay of Todos Santos, &c., and continuing southward came in sight of the island of San Hilario.

It is in latitude 30° 29′, lies three miles off the coast, and is nearly ten miles northwest from the cape.

"The island is nearly circular in form, having its greatest diameter (one and a half miles) in an east and west direction. There are two remarkable peaks near the center. The western, which is 497 feet high, is an *extinct volcano* having a crater at its summit 350 feet in diameter and 40 feet deep. The island is quite barren, producing nothing but the prickly pear and a few stunted bushes, that grow among the loose masses of lava.

"There is good anchorage on the southeast side of the island, off a small lagoon which has communication with the sea at half tide; and anchorage may be found anywhere on the northeast side. The best place to anchor in is Hassler Cove, a snug little bight on the eastern side of the island, protected on all sides except the north. Anchor in seven to nine fathoms with the northern end of the natural breakwater that forms the east side of the cove, bearing S. 57½° E. true. The island is surrounded by detached rocks and kelp; and great numbers of seal and sea fowl resort to it, particularly to the shores of the cove and the lagoon" (p. 8).

Torquemada says that the Island Cenizas is divided in the middle, making two high mountains. Ferrelo does not mention on which side of the island the drift timber was found, but evidently on the east, where he anchored. [See memorandum about the Spanish cedar found at Scammon's Lagoon.]

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They departed from this Puerto de la Posesion Sunday, the twenty-seventh of the said month of August, and sailing on their course found an island two leagues from the mainland; it is uninhabited; there is a good port in it; they gave it the name of San Augustin; it measures two leagues in circumference; and so they held on along the coast with light winds, working to windward, until the following Wednesday, the thirtieth of said month, which gave them much wind from the northwest, which compelled them to put into the island of San Augustin. In this island they found some sign of people, and two cow-horns, and very large trees which the sea had cast there, which had more than sixty feet in length, and were of such thickness that two men could not embrace one of them; these appeared to be cypresses, and there were cedars. There was a large quantity of this wood; it contains nothing else. If a good port, it is not a valuable island; they were at this island until the following Sunday.

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San Ramon Bay, latitude 30° 49′.

For twenty-one miles north of San Martin Island the coast-line runs nearly true north and south, and then forms the broad bight known as San Ramon Bay or Virgins Bay. Thence the shore of sand dunes runs northwest to the

FERRELO.

On Sunday, the third day of September, they departed from the said island of San Augustin, and proceeded, sailing on their course, and the following Monday they dropped anchor about seven leagues distant on the windward shore, on a coast running north and south; and then they

When the Almiranta stood inshore from the island of Paxaros or Guadalupe she made the coast just north of the island of San Martin, and "they saw the island of Ceniza, that was left behind them (p. 80); that those of the Capitana had not seen; and prosecuting the search for the Capitana and the Fragata; and coming into the Bahia de las Virgines, they saw the Capitana and tender sailing out to sea: * * * and the General gave orders to continue their course to the first harbor they should find. Accordingly they passed near a small island close to the mainland, which they called San Hilario * * * (p. 80).

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bay under Cape Colnett, to neither of which does Ferrelo refer, unless he means the bay under Cape Colnett when he says he anchored in the Ensenada which the island forms. The coast hence runs eighteen miles true north. There is a broad valley northward of Cape Colnett and then jagged mountains.

For fifteen miles southeast of Cape Colnett the kelp field is very dense in thirteen fathoms of water. On the other hand, he may have anchored in the broad indentation sixteen miles north (true) from Cape Colnett, off the mouth of the San Vicente River. Five miles off the shore soundings are had in thirteen fathoms of water. A few miles in the interior the mountains attain an elevation of 1,500 to 2,000 feet. At eight or ten miles inland is the old Mission of San Vicente.

Cabo de San Simon y Judas, Vizcaino's chart.
Cape Colnett, in latitude 30° 59′.
La Bahia de San Simon y Judas, Vizcaino (pp. 81, 84).
Colnett Bay.

Cape Colnett is a remarkable headland. Its shore outline is semicircular, with perpendicular cliffs, from 150 to 350 feet high, of a very dark-colored rock which forms the upper horizontal layer or stratum, based on a light sandstone. The coast retains the same general appearance for ten miles to the northward of the cape. The eastern shore of the cape trends north and eastward for two and a half miles, forming Colnett Bay, where good anchorage may be found abreast a remarkable gorge in from six to nine fathoms of water over a sandy bottom. Ten to fifteen miles southward of the cape the coast sweeps around to the southward, forming what is called on the charts San Ramon Bay, as already mentioned. Ten miles behind Cape Colnett the mountains rise to 1,500 and 2,000 feet elevation. Neither Cabrillo nor Ferrelo refers to this notable headland to the bay.

This is the first time that Ferrelo mentions currents from the northward.

El Cabo de San Martin, 32½°. Ferrelo.
Cape San Tomas, or Point Santo Tomas; latitude 31° 33′; correction to Ferrelo, —0° 57′.

Ferrelo's description means a narrow promontory or sharp cape formed by a spur or ridge of the mountains projecting from the interior and ending in a high point.

Vizcaino makes no mention of this cape in his narrative; but he has the projecting point on his chart, and behind it the legend "mountainous."

"The point lies twelve miles S. 14° E. from Banda Point. The coast-line between them is crescent-like, high and precipitous, with deep water close inshore, and numerous detached rocks. The point itself is low and rocky, rising abruptly to a height of 395 feet, where it unites with the coast mountains, which attain, at five or six miles inland, an elevation of 4,520 feet. * * * Half a mile to the southward of the point the coast makes a sharp turn to the eastward, forming a small bight, where good anchorage may be found one quarter of a mile from shore, in five to six fathoms of water, over sandy bottom, sheltered from the prevailing coast winds. A stream running through a deep cañada opens on the beach two miles southeast of the anchorage; a road leads from abreast this anchorage to the mouth of this stream, and thence to the old Mission of Santo Tomas, situated sixteen miles

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continued their course and were sailing with fair weather, on a coast running north and south, until Thursday, the seventh day of the said month of September, when they cast anchor in a cove which the land forms; and here ends the coast, which runs north and south and turns to the northwest. Behind this cove there is a large valley, and the land is level on the coast, and within are high ranges, and rough land good in appearance. All the coast is bold with a smooth bottom, as at half a league from land they were at anchor in ten fathoms; here there is much vegetation on the water.

On the Friday following, on the eighth of the said month, they held on with light winds, working to windward, and they found here contrary currents;

they dropped anchor under a point which forms a cape, and affords a good shelter from the west-northwest; they gave it the name of Cabo de San Martin; where the land terminates on both sides; and here also terminates a chain of high mountains that are beyond in the distance, and end by other smaller sierras. There is a large valley and many others; in appearance it is good land; it is in thirty-two and a half degrees, and is a clean port and soundable; it trends with the island of San Augustin, north and south.

Being at this Cabo de San Martin, they went on shore for water, and found a small lagoon with fresh water, where they procured water, and at this watering-place came forty Indians with their bows and arrows; they could not understand each other; they came naked; they brought roasted agaves to eat and fish; this is an advanced race; here they took possession; they were at this cape until the following Monday.

(P. 80.) "And ranging along the coast [northward from Isla de San Hilario] they came in sight of a large bay, which the General ordered the tender to sound and survey; and they found it afforded a very good shelter against the northwest wind (p. 81), and there were many Indians, and going further north about two leagues they were overtaken by a strong gale at northwest which obliged them to put back into the said bay; and it being the anniversary of the glorious Apostles Saint Simon and San Judas, October 28th, they gave that name to the bay. Here the General ordered the Almiranta to take in wood and water. * * * Near the shore they found a considerable number of Indians, who were alert and courageous" (p. 81). [They had a fight with the Indians, * * * and left the bay on the first of November.]

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inland, in a very fertile valley. A smaller stream opens directly opposite the anchorage."

In 1873, when passing this point, we made the following note which may explain Ferrelo's peculiar expression, "As seen from the northwest, the point of Solitarios shows vertical dykes" (with illustrations).

The anchorage is called "Sheltered Cove" in the Coast Survey Chart of 1874.

FERRELO.

El Cabo de la Cruz; 33° Cabrillo.
El Cabo de Cruz; 33° Ferrelo.
Grajero Point, in latitude 31° 45′.
Banda Point, on some charts.
Correction to Cabrillo and Ferrelo, —1° 15′.
Las Islas de Todos Santos.
La Ensenada de Todos las Santos; Vizcaino (p. 121).
Todos Santos Bay.

Ferrelo does not describe this great bay as a whole, but in embarrassing details; and on account of adverse winds his estimates of distances are very erroneous. He barely mentions passing a small island, which must be Todos Santos Island.

Grajero Point is a very bold, narrow head, projecting five miles into the sea to the west-northwestward, and increases in width from a quarter of a mile to two miles. Near the extreme point the height is 1,273 feet; and in three and a half miles from the coast-line, between this cape and Point Santo Tomas the mountains rise to 3,563 feet. The sides of the cape are precipitous and slope both ways (N. NE. and S. SW.).

The Todos Santos Islands are on the prolongation of the cape and distant three miles therefrom. Their combined length is two miles, and the width half a mile. The southeast islet rises 374 feet, and the northwest islet about 60 feet. They lie about the middle of the entrance to the bay, which is nine miles broad by as many deep. In the southeast part of the bay there is a broad sand beach behind which lies a lagoon receiving the waters of two small streams. Vizcaino indicates this low shore by a discontinued line. In the northeast part of the bay is the Ensenada anchorage, and under the northwest cape, called San Miguel, is the anchorage abreast the Arroyo Carmen. Very high mountains surround the bay. A favorable wind induced Vizcaino to postpone the survey of the bay until his return voyage, when he was unable to carry out his plan.

Monday, on the eleventh of said month, they departed from Cabo de San Martin and sailed about four leagues on a coast running from north-northeast to south-southwest, ([6]) and thence the coast turns to the northwest. The land is lofty and bare; and the day following they sailed also with adverse winds about four leagues on a coast running from northwest to southeast. On the land there are high and broken sierras; and the following Thursday they dropped anchor at about three leagues in advance at a point which projects sharply into the sea; they called it Cabo de Cruz; it is in thirty-three degrees; there is no water nor wood, nor did they find any signs of Indians.

Having departed from Cabo de Cruz, they found themselves the following Saturday two leagues from Cabo de Cruz on account of the head winds on a coast from north-north-west to south-southeast, and under the shore they saw Indians in some very small canoes. The land is very high and bare and dry. All the land from the extremity of California to this place is sandy like the sea-beach. Here begins land of another character, as it is a country of beautiful vegetation and better appearance, like orchards.

El Puerto de San Mateo, 33⅓°, Ferrelo.

This "port" may be the present Ensenada anchorage in the northeast part of Todos Santos Bay, where his description suits very well; he very probably passed outside the Todos Santos Islets to get there. It is well sheltered from all winds but the southwest, and he would have to get water by digging or from water-pools filled by the early rains. It is only nine miles in a direct line from his Cabo de Cruz. It is in latitude 31° 51′, and the correction to Ferrelo's latitude would be, —1° 29′. If he passed outside the islets it is a possibility that he was under Cape San Miguel or Sausal Point, which forms the northwestern limit of Todos Santos Bay, and lies six and a half miles from the Ensenada anchorage. The cliffs are bold and high, and he could have gotten water from the Arroyo Carmen, but he would have been exposed to the heavy swell from seaward.

Sunday, the seventeenth of the said month, they set sail to pursue their voyage, and about six leagues from Cabo de Cruz they found a good port well enclosed, and to arrive there they passed by a small island which is near the mainland. In this port they obtained water, and there are groves resembling silk cotton trees [ceybas], except that it is hard wood. They found thick and tall trees which the sea throws ashore. This port was called San Mateo. It is a good country in appearance. There are large cabins, and the herbage like that of Spain, and the land is high and rugged. They saw herds of animals like flocks of sheep, which went together by the hundred or more, which resembled in appearance and movement Peruvian sheep, and with long wool. They have small horns of a span in length as thick as the thumb, and the tail is broad and round and of the length of a palm. It is in thirty-three and one-third degrees. They took pos-

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On the fourteenth of September they came to anchor at a cape, which they called de la Cruz; land precipitous, high, and barren, which is in thirty and three degrees.

"The squadron having left the bay of St. Simon and St. Jude (p. 84), and continuing their voyage against the wind, and against the currents, they came very near to a great bay nearly surrounded by lofty mountains; and by the breaking of the sea near the harbor, it appeared that it was an arm of the sea or the mouth of a river. In the west part of the bay, about two leagues distant, there are two islands which they call Todos Santos The tender being ordered in, the Almiranta followed her; but the Capitana, as night was coming on, stood off to sea; and the others, that they might not be separated from her, also put back. This happened on the 5th of November, and the next morning it was agreed to stand again into the bay and take a plainer view of it, but a favorable breeze springing up and the General thinking it most advisable to take advantage of it, and refer the survey to their return, they continued their course."

[About the end of January, 1603, Vizcaino was returning to La Paz for succor (p. 121); many of his crew being dead from scurvy and only three or four remaining fit to navigate his ship. The winds were light and he made but slow progress, but he carried the ships to the springs or wells which he had previously found in the deepest part of the Ensenada de Todos los Santos.

Under these circumstances his description is very meagre.]

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Neither the Coast Pilot nor the chart notes any anchorage, although it is reported that schooners have recently anchored here.

Cape San Miguel lies nine miles true north from the Southern Cape of Todos Santos Bay, and is in latitude 31° 33½′. This would give a correction to Ferrelo of —1° 30. He was in the region of the antelope, which were still running in large herds around San Diego Bay in 1851.

There is a remarkable valley opening on the coast in 32° 06′. It exhibits several marked terraces reaching back and up to a great height above the sea.

Cabrillo must have been near Descanso Bay in latitude 32° 16′, but the distance is only twelve leagues.

FERRELO.

session of it. They were in this port until the following Saturday.

Saturday, the twenty-third of the said month, they departed from the said port of San Mateo and sailed along the coast until the following Monday, in which time they made about eighteen leagues. They saw very beautiful valleys and groves, and a country flat and rough, and they did not see Indians.

DAVIDSON.

Las Islas Desiertas, 34°, Ferrelo.

Las Islas de los Coronados, Vizcaino (page 85).

Las Islas de San Martin, chart of Vizcaino.

Los Coronados Islands, in latitude 32° 25′. Correction to Ferrelo's latitude,—1° 35′.

This is a group of four or five rocky and desolate islets. There are two main islets and three smaller masses of rocks. The largest islet is about seven miles from the coast-line, and the others stretch to the northwest for four or five miles. The largest is two miles long by half a mile wide; it is wedge-shaped, and at its highest peak attains an elevation of 674 feet. On the west and northwest sides lie two barren rocks fifty feet high. The northwestern islet is a barren rock seven-tenths of a mile in extent and 350 feet high. A fair anchorage may be had in eight fathoms of water over sandy bottom, on the east side of the islet, northward of its middle.

Kohl says: "There is little doubt that the 'Dolores' mentioned by Taraval were the Coronados Islands"! We have already shown that Taraval landed on Natividad and Cerros Islands.

FERRELO.

On the Tuesday and Wednesday following they sailed along the coast about eight leagues and passed by some three uninhabited islands. One of them is larger than the others, and extends two entire leagues, and forms a shelter from the west winds. They are three leagues from the mainland; they are in thirty-four degrees. This day they saw on the land great signal smokes. It is a good land in appearance, and there are great valleys, and in the interior there are high sierras. They called them Las Islas Desiertas.

DAVIDSON.

La Mesa de la Cena, Vizcaino's chart.

La Mesa Redonda of the native Californians.

Table Mountain, in latitude 32° 20′ 05″, longitude 116 54′ 17″.

This is a notable mountain, especially as a landfall to the navigator; and Vancouver gives a characteristic view of it. It lies about seven miles inside the shore of Descanso Bay. As seen from every side it is flat topped, and the top nearly circular. The surface of this table is covered with singular fragments of rock. The diameter of the flat top is 1,60 0 yards, and its height above the sea is 2,244 feet; so that it is visible at fifty miles from seaward. A few miles to the southeast of this mountain there is another marked mountain of three sharp peaks rising 400 to 500 feet higher than Table Mountain. It seems curious that Cabrillo did not mention these mountains.

THE COAST OF ALTA CALIFORNIA.

El Puerto de San Miguel, 34⅓°, Ferrelo.

El Puerto de San Diego, Vizcaino.

El Puerto Bueno de San Diego, Vizcaino's chart.

San Diego Bay. The light-house near the extremity of Point Loma is in latitude 32° 40′. Correction to Ferrelo,— 1° 40′.

El Buen Puerto, Vizcaino.

False Bay.

FERRELO.

The Thursday following they proceeded about six leagues along a coast running north-northwest and discovered a port enclosed and very good, to which they gave the name of San Miguel. It is in thirty-four and one-third degrees; and after anchoring in it they went on shore, which had people, three of whom remained and all the others fled. To these they gave some presents; and they said by signs that in the interior had passed

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"After sailing a few leagues, the wind again shifted to the northwest, but they kept coasting along the shore, and were amused by the smokes and fires made by the Indians all along the Strand as an invitation to the ships to send their people ashore. The country appeared very beautiful, and level, and pleasant. At the distance of six leagues from the mainland, they fell in with four islands, to which they gave the name of Los Coronados (p. 84); the two smaller appear like sugar-loaves, the other two somewhat larger."

[On his chart he names them Las Islas de San Martin, and has a anchorage on the north side of the largest.]

[Vizcaino's chart places the "Mesa de la Cena" near the coast-line to the southward of the Coronados. It furnishes the only attempt at hachuring on Burney's copy of his chart and therefore must have impressed the cosmographer.]

"To the north of these islands [Los Coronados] (p. 85), on the mainland is a famous harbor which was named the Puerto de San Diego, which the squadron entered at seven in the evening of San Martin on the tenth of November. The day following the General ordered several persons to survey a hill (monte) [La Loma] which afforded protection to this port from northwest winds. * * * On this hill they found tall and straight oaks, and other

DAVIDSON.

La Isla de Arena.

The Peninsula. "The Island" is the low sandy, chaparral-covered peninsula, forming the west shore of the bay and crowding so close to Ballast Point under Punta de la Loma as to form the deep narrow channel between the bay and the sea. It is not over six feet above the level of the sea, and in 1850 was locally known as "The Island," and now known as the "Peninsula."

Next to that of San Francisco, no harbor on the Pacific coast of the United States approaches in excellence the Bay of San Diego. It is readily distinguished by the notable landmark of Point Loma, in latitude 32° 39′, is easily approached on account of the absence of outlying dangers, and a depth of twenty-two feet of water can be carried over the bar. This bar has not changed in depth or position since the time of Vancouver.

Vessels approaching San Diego Bay make the ridge of Point Loma as a long flat-topped island, when about twenty-five miles distant. This appearance is occasioned by the bay to the southwest, by the low land to the northeast, and by the Puerto Falso at the north.

The bay is a long curving body of water about twelve miles in length, and from one-half to ten miles in width. For the first six or seven miles from the entrance there is a fine broad channel, carrying four to eight fathoms of water. The southern end of the bay is occupied by very extensive flats, through which a channel with twenty to twelve feet of water is found. Between the bay and the ocean there is a narrow strip of sand dunes and very low ground.

When inside the entrance of the bay, a vessel is sheltered from every wind, and the holding ground is good.

When we first visited the bay, in 1851, there was no sign of the trees mentioned by Vizcaino, nor did the Spanish population have any traditions about them. His description of "el monte" applies with great directness to La Loma.

Kohl blunders very badly about Taraval's "Bahia de San Xavier," and says that "probably it is the small bay now known as San Diego Harbor." We have shown that it was the great gulf of Sebastian Vizcaino lying eastward of Cerros Island.

FERRELO.

people like the Spaniards. They manifested much fear This same day at night they went on shore from the ships to fish with a net, and it appears that there were here some Indians, and they began to discharge arrows and wounded three men.

The next day, in the morning, they entered farther within the harbor, which is large, with the boat, and they brought away two boys, who understood nothing by signs, and they gave them both shirts, and immediately sent them away.

And the following day, in the morning, there came to the ship three full-grown Indians, and by signs they said that there were travelling in the interior men like us, with beards, and clothed and armed like those of the ships, and they made signs that they carried cross-bow and swords, and made gestures with the right arm, as if they were throwing lances, and went running in a posture as if riding on horseback, and made signs that they killed many of the native Indians, and that for this they were afraid. This people are well-disposed and advanced; they go covered with the skins of animals. Being in this port, there passed a very great tempest, but on account of the harbor being good, they suffered nothing. It was a violent storm from the west-southwest and south-southwest. This is the first storm which they have experienced. They were in this port until the following Tuesday. Here Christians were called Guacamal.

DAVIDSON.

Ensenada (de Santa Cathalina), Vizcaino.

San Pedro Bay, latitude 33° 43′.

To Vizcaino this great bight embraced the low country north and east of San Pedro Bay, which land he did not see. On his chart he places Santa Catalina Island broad off the Bay of San Pedro.

Kohl thinks that San Pedro Bay is the Baia de Fumos of Cabrillo, but we will show that it is Santa Monica Bay.

FERRELO.

The following Tuesday, on the third day of the month of October, they departed from this port of San Miguel, and Wednesday and Thursday and Friday they proceeded on their course, about eighteen leagues along the coast, on which they saw many valleys and much level ground, and many large smokes, and, in the interior, mountains.

DAVIDSON.

La Isla de San Salvador, Ferrelo.

La Isla de Santa Cathalina, Vizcaino.

Santa Catalina Island, in latitude 33° 26¼′, at Isthmus Cove.

The island is eighteen miles from the mainland at San Pedro and twenty-three and a half miles from Point Lasuen.

La Isla de la Vittoria, Ferrelo.

San Clemente Island; the latitude of the southeast head is 32° 49′.

These islands were named after the ships; the former

FERRELO.

They were at dusk near some islands, which are about seven leagues from the mainland, and because the wind had died out they could not reach them this night.

Saturday, the seventh day of the month of October, they arrived at the islands at daybreak, which they named San Salvador and La Vittoria, and they anchored off one of them, and they went with the boat on shore to see if people were there, and as the boat approached, a great number of Indians issued from among the bushes and grass, yelling and dancing and making signs that they should come ashore; and they saw that the women were

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trees; some shrubs resembling rosemary, and a great variety of fragrant and wholesome plants. The top of this hill commanded a view of the whole harbor which appeared very great and very commodious, and well sheltered from every wind (p. 86). The hill borders this harbor on the northwest and is about three leagues in length, and a half a league in breadth. And to the northwest of this hill is another good harbor. * * * They obtained there water from a sandy beach or a little island of sand, where they dug deep trenches, in which, during the flood the water was fresh and good; but on the ebb salt. * * * Most of the Indians painted or besmeared with black and white; and their heads were loaded with feathers. * * * They signified by signs that a certain people up the country had beards and were clothed like the Spaniards (p. 88); and by their dress, complexions, and customs seemed to be of the same country with the visitors. * * *

"In this harbor there is a great variety of fish, as oysters, mussels, lobsters, soles, &c., and the country abounded in game. * * * They were highly delighted with the mildness of the climate, and the goodness of the soil. * * *

"Everything being completed, * * * they left this place on the twentieth of November (p. 89).

"They had no sooner left San Diego, than the northwest wind commenced to blow (p. 89). Little by little, however, the ships advanced, and came in sight of a great gulf, where the neighboring country presented a very pleasant appearance. And as they proceeded they saw also the smoke of large fires which the Indians had kindled, to induce the ships to put in there. But on approaching the coast, found no shelter from the northwest wind; they therefore continued their course, and a few leagues further discovered (p. 90) a great island about twelve leagues from the mainland, and for the day of its discovery, they called it the Isla de Santa Cathalina. On the 28th of November the ships came close in with it, and from thence had sight of a much larger one lying to the southwest of Santa Cathalina. They, however, thought proper not to survey it till their return (p. 90). [Then follows a long description of the inhabitants, &c.]

(P. 94) "This island, like most of those adjacent, is very populous. * * * This island has several good harbors, abundance of fine fish, especially large and good sar-

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after the flag-ship, the Capitana, and the latter after the tender, the Almiranta.

These two islands are large, very high, and visible far out at sea. I have seen the former from the ridge of Point Loma.

Santa Catalina Island is eighteen miles long, with an extreme breadth of seven miles, and an average breadth of four miles. Its general direction is W. by N. ¾ N., magnetic. It rises to 2,110 feet above the sea, and is visible at a distance of fifty-three miles. It is very rugged, covered largely with dense chaparral, and is nearly divided into two islands towards the western end.

San Clemente Island is also eighteen miles long, and not over three and a half miles broad; it rises to 1,964 feet elevation, and is visible at a distance of fifty miles. It lies nearly parallel with Catalina, and directly south; its north point is only nineteen miles from the nearest part of Catalina.

Neither island has been inhabited by Indians since the country has been settled by Americans, and the signs of former populations are much less than on Santa Rosa and San Miguel. For further descriptions see Davidson's Coast Pilot.

Ferrelo evidently anchored off the north side of Santa Catalina Island.

Vizcaino does not mention San Clemente by name, but describes it as a larger island lying to the southwest, and to be surveyed on the return of the expedition from the north. He has not placed it on his chart.

On his plan of Catalina Island he clearly indicates the locality of the great depression; and a small circle denotes the position of the so-called Temple to the Sun, &c.

FERRELO.

running away, and from the boats they made signs that they should have no fear, and immediately they assumed confidence and laid on the ground their bows and arrows, and they launched a good canoe in the water, which held eight or ten Indians, and they came to the ships. They gave them beads and little presents, with which they were delighted, and they presently went away. The Spaniards afterwards went ashore and were very secure, they and the Indian women and all. Here an old Indian made signs to them that on the mainland men were journeying, clothed and with beards like the Spaniards. They were in this island only until noon.

DAVIDSON.

La Bahia de los Fumos, 35°, Ferrelo.

La Bahia de las Fuegos, Ferrelo.

La Bahia Ona, a corruption of La Ballona, a rancho bordering this bay.

Santa Monica Bay, named from the Sierra Santa Monica. Latitude of Point Dume on the northern shore of the bay 34° 00′; correction to Ferrelo,—1° 00′.

I feel sure that he made the land of this bay near Point Dume, where there is shelter, and where there were large rancherias of the Indians to a very late date.

Vizcaino does not mention this bay, but it is plainly indicated on his chart, as well as the cape formed by San Pedro Hill, 1,475 feet elevation.

Ferrelo does not mention San Pedro Bay, but Vizcaino calls it an Ensenada, embracing Santa Catalina Island; and his chart gives it great breadth, and notes the rocky islet called Deadman's Island. This islet is the El Morro of the later Spanish charts.

This part of the coast is sharply backed on the north by the almost inaccessible mountains of the Sierra Santa Monica. To this day they may be said to have no trails through them.

FERRELO.

The following Sunday, on the eighth of the said month, they came near the mainland in a great bay which they named la Bahia de los Fumos; on account of the numerous smokes which they saw around it. Here they held intercourse with some Indians, whom they took in a canoe, who made signs that towards the north were Spaniards like them. This bay is in thirty-five degrees, and is a good harbor, and the country is good, with many valleys and plains and trees.

DAVIDSON.

Laguna Mugu, latitude 34° 05′.

This is a moderately large estero under the northwesterly coast termination of the Sierra Santa Monica, where it crowds over the broad low plains of the Santa Clara Valley. There is a good anchorage off the mouth of the estero. See 'Davidson's Coast Pilot of California, Oregon, and Washington.'

FERRELO.

The following Monday, on the ninth day of the said month of October, they departed from la Bahia de los Fuegos, and proceeded this day about six leagues, and anchored at a large inlet,

dines. * * * The sea wolves serve the Indians both for food and clothing. * * * After taking a survey of several parts of this Island, the squadron left it on the third of December, 1602.

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It is fifteen miles west of Point Dume. From Mugu to San Buenaventura the coast-line is nineteen miles, and the last eight miles runs northwest. This is the only coast-line in this section with this direction and with such a well-marked valley.

Los Pueblos de las Canoas, 35½°, Cabrillo.

El Pueblo de las Canoas, 35⅓°, Ferrelo. ("Which is called Xucu.") Ferrelo, page 84.

San Buenaventura, in latitude 34° 17′; correction to Ferrelo,—1° 03′.

San Buenaventura lies under the seaward face of the mountains, at the extreme western edge of the broad, low, flat valley of Santa Clara. The Santa Clara River empties into the ocean four or five miles eastwardly of San Buenaventura, while on the immediate west empties the San Buenaventura River, after coming through a smaller and narrow valley among the mountains. The wood, fresh water, open bay, plains on one side and river on the other would make this a favorable location for a large village. Ferrelo's description is very satisfactory, and it will not suit any other locality in this immediate region.

Vizcaino sailed past this part of the coast with favorable winds, and did not anchor anywhere in the archipelago, except at Santa Catalina; but he notes the projecting shore-line at Point Hueneme, and to the west of it lays down on his chart a large "fresh-water river," which may be either the Santa Clara or the San Buenaventura, more likely the former. He held short communication with the chief of the Indians.

The founding of the Mission of San Buenaventura would indicate that large numbers of Indians were in the vicinity, and that the place had superior inducements for sustaining the establishment and recruiting proselytes.

The name Taquimine seems to be the original of the present Hueneme, and is locally referred to the name of a celebrated chief.

Mugu (Point Mugu) is quite likely the original name of one of their villages, although it may be from the Spanish muga, which really designates the character of the point.

We may here premise that hence to Point Concepcion Ferrelo gives the distance at thirty leagues, whereas it is only between twenty and twenty-one leagues, and we may reasonably be guided in the adoption of this scale through the Santa Barbara Channel, because he had pleasant weather and light variable winds throughout.

But pending that examination along the main shore I refer to the other two islands not seen by Cabrillo and Ferrelo.

La Isla de Santa Barbara, Vizcaino's chart.

Santa Barbara Island.

He has not mentioned it individually in his narrative. It is laid down as a small island in a relatively correct position. His name is retained. This island is in latitude 33° 30′, and rises 547 feet above the sea; it can be seen a distance of twenty-seven miles.

La Isla de San Nicolas, Vizcaino.

San Nicolas Island.

The southeast point is in latitude 33° 16′. It is not

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and they passed on thence the following day, Tuesday, and proceeded about eight leagues on a coast northwest and southeast, and they saw on the land a village of Indians near the sea, and the houses large, in the manner of those of New Spain; and they anchored in front of a very large valley on the coast. Here came to the ships many very good canoes, which held in each one twelve or thirteen Indians, and they gave them information of Christians who were journeying in the interior. The coast is from northwest to southeast. Here they gave them some presents, with which they were very much pleased.

They made signs that in seven days they could go where the Spaniards were travelling, and Juan Rodriguez was determined to send two Spaniards to the interior. They also made signs that there was a great river. With these Indians they sent a letter at a venture to the Christians. They gave the name to this village of el Pueblo de las Canoas. They go covered with some skins of animals; they are fishermen, and eat the fish raw; they also eat agaves. This village is in thirty-five and one-third degrees. The country within is a very beautiful valley, and they made signs that there was in that valley much maize and much food. There appear within this valley some mountains very high, and the land is very rugged. They call Christians Taquimine. Here they took possession: here they remained until Friday, the thirteenth of the said month.

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Tuesday, on the tenth of October, they discovered some villages of peaceable Indians, with whom they traded, which they named los Pueblos de las Canoas, because they had a great many canoes, and they are in thirty and five degrees and a third;

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mentioned in his narrative, but is on his chart, where it is placed close alongside and to the westward of Santa Barbara Island, and even smaller. He has either committed the error that Tebenkoff has done in his atlas (1848) of laying down Santa Barbara as two islets, or he saw only the highest point of San Nicolas Island, which is 890 feet above the sea and visible at a distance of thirty-four miles. Supposing that he sailed from the north harbor of Santa Catalina Island to the throat of the Santa Barbara Channel (reckoned as lying between Anacapa Island and Point Hueneme), he passed not nearer than fifteen miles to Santa Barbara Island and forty-two miles to San Nicolas Island. The former is visible in clear weather with a sharp lookout; the latter is not visible unless by extraordinary refraction.

As Vizcaino gives a graphic description of his passage through the Santa Barbara Channel, we interrupt Ferrelo's narrative to condense it.

The Islands of the Santa Barbara Channel.

To the broad passage between the mainland from Point Hueneme to Point Concepcion and the islands from Anacapa to San Miguel, Vizcaino (p. 95) gives the name El Canal de Santa Barbara. He is the first to call attention to the parallelism of these islands with the continental shore.

This channel is sixty-five miles long nearly east and west, and ranges from eleven to twenty-six miles in breadth. His statement that there are six islands in this channel must include the islands which he named San Nicolas and Santa Barbara, and which are laid down by him half way between Santa Catalina Island and Anacapa. His chart gives a very fair representation of the archipelago and its relation to the mainland. This archipelago is now known as the Santa Barbara Islands, and embraces all of them from San Miguel to San Nicolas and San Clemente.

Cabrillo's vessels left Buenaventura and reached the "Rincon," latitude 34° 22′, four leagues west of San Buenaventura. This coast is bordered by high and steep mountains, the water is alkali, and it was doubtless but sparsely inhabited.

Friday, the thirteenth of the said month of October, they departed from the Pueblo de las Canoas on their voyage, and proceeded this day six or seven leagues, and passed two large islands which extend four leagues each one, and are four leagues from the continent. They are uninhabited, because there is no water on them; and they have good ports.

(Pp. 94, 95.) Beyond Santa Catalina there is a regular row of islands from four to six leagues distant from each other. Some are large and others small, but all are populous, and the inhabitants trade with each other and with those of the continent. These islands take up from the first one to the last one, nearly a distance of one hundred leagues; and they follow each in the same direction as the mainland; and their number, largeness, and proximity often occasion the Philipine ships in their return to New Spain, to mistake them for the Continent; and thus to keep at a distance from them. They are, however, very populous, and have a safe passage betwixt them and the mainland, in some parts twelve, in others ten, and the narrowest eight leagues broad, called *el Canal de Santa Barbara*, and which lies East and West. The ships being arrived near the continent, at the mouth of this Canal, a boat came off with four paddles, bringing an Indian, who was the King of the Coast on the mainland. * * * Within an hour after the Indian was gone, a southeast wind sprang up, and was the only gale from that quarter they had felt during their voyage. And it being directly fair, the General thought proper to defer his visit to the Indian King till his return. * * * Accordingly they set all their sails, and as the gale lasted from seven in the evening of the 3rd of December till eight o'clock the day following (p. 98), the ships had nearly reached the last cluster of islands in the Canal, which are six in number, and distant two leagues from each other. The Canal is about twenty-four leagues in length, and the coast of the continent very pleasantly interspersed with woods, and has a great number of Indian Villages. In the night following the day of Santa Barbara the wind shifted to the northwest, which caused great consternation, it being dark, and the ships among islands and in the channel where the sea ran very high. This gale lasted all night and the following two days; on the third it abated; but they had lost sight of their consort among the islands on the day of San Nicolas. With fair weather the ships sailed out of this archipelago. * * *

DAVIDSON.

La Isla de gente Barbada, Vizcaino's chart.
Anacapa Island, latitude 34° 01′.

This island is distinctly visible from San Buenaventura, and is distant seventeen miles, although not nearly so large as mentioned by Ferrelo. It is four and a half miles long but very narrow, and presents its broad side to the northern shore west of San Buenaventura. In approaching it from the east, from under Point Dume, it is seen projected on the Island of Santa Cruz, and cannot be distinguished from it if the atmosphere is very clear. In this case the whole mass of the two islands, and even a part of Santa Rosa to the south, will show as one very large island, and when seen from San Buenaventura it might be supposed that only the end was visible towards the observer, and thus a stranger would be misled in his estimate of the size, &c.

The island is merely a great ridge of coarse sandstone rock reaching 980 feet elevation, barren, desolate, without water and without a harbor. When Vizcaino was approaching it he must have supposed it was a great island, and he even lays it down on his chart with its greater length to the southwest.

The second island seen by Cabrillo is La Isla de San Ambrosio of Vizcaino's chart, with a rocky islet laid down off its eastern point. This is the Island of Santa Cruz, of which the eastern point is in latitude 34° 02′.

Ferrelo has evidently confused the characteristics of the two islands, because he visited neither, saw them under changing aspects, and got his information from the Indians by signs.

The name Anacapa is a corruption of Vancouver's Indian name of the island. In his text he names it Enneeapah, but the engraver has spelled it Enecapah on the chart, and subsequent compilers have endeavored to give it a Spanish form. The Indian deep guttural pronunciation is En-ni-ah-pagh′.

The vessels left the Rincon where the low lands of the Carpinteria begin and stretch westwardly for ten miles to Santa Barbara Point. He anchored off the Carpinteria, latitude 34° 24′, about a mile west of Sand Point. Ferrelo's description is satisfactory.

From the Carpinteria the vessels continued past Santa Barbara (at six and a half miles from his starting point) with its protecting hill, La Vigia, and the rocky cliffs of the mesa for five miles to the westward of the anchorage; past the low shore and treeless mesa cut by the lagoons behind Point Goleta; and anchored about four or five miles west of the latter place, probably inside the great field of kelp skirting the coast; latitude 34° 25′.

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The coast of the mainland runs west-northwest; the country is level, with many cabins and trees; and the following Saturday they continued on their course, and proceeded two leagues, no more, and they anchored opposite a valley very beautiful and very populous, the land being level with many trees. Here came canoes with fish to barter; they remained great friends.

And the Sunday following, the fifteenth day of the said month, they held on their voyage along the coast about ten leagues, and there were always many canoes, for all this coast is very populous, and many Indians were continually coming aboard the ships, and they pointed out to us the villages and named them by their names, which are Xucu, Bis, Sopono, Alloc, Xabaagua, Xotococ, Potoltuc, Nacbuc, Quelqueme, Misinagua, (6) Misesopano, Elquis, Coloc, Mugu, Xagua, Anacbuc, Partocac, Susuquey, Quanmu, Gua, Asimu, Aguin, Casalic, Tucumu, Incpupu. All these villages extend from the first, Pueblo de las Canoas, which is called Xucu, as far as this place; they are in a very good country, with very good plains and many trees and cabins; they go clothed with skins; they said that inland there were many towns, and much maize at three days' distance; they call the maize Oep; and also that there were many cows. They call the cows Cae; they also gave us notice of some people with beards, and

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La Isla de San Lucas, Ferrelo.
Las Islas de San Lucas, Ferrelo. (See pp. 205, 226, 228.)

They supposed that Santa Cruz Island and Santa Rosa Island were one, because they saw them overlapped. They afterwards discovered them to be two islands, referring in January, 1543, to Santa Cruz Island as "the other islands of San Lucas," which the Indians called Limu or Limun, and to which the discoverers gave the name of San Salvador, forgetting that Santa Catalina had already received that name from them. It is the present Santa Cruz Island. The highest peak is Mt. Diablo (Devil's Peak), which is 2,410 feet above the sea, and is visible at a distance of fifty-five miles. The six villages which Ferrelo here names have not a single correspondent in the names of the thirteen villages which he subsequently learned to be on the three western islands.

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clothed. They passed this day parallel with the shore of a large island which is fifteen leagues in length, and they said that it was very populous, and that it contained the following villages: Niquipos, Maxul, Xugua, Nitel, Macamo, Nimitopal. They named the island San Lucas; it is from this place to Pueblos de las Canoas eighteen leagues; the island is from the continent six leagues.

On the 16th of October they sailed from the anchorage (four or five miles west of Goleta Point or eleven miles west of Santa Barbara Light-house) to an anchorage twenty or twenty-one miles west of the same light-house, and very likely abreast the opening of the Cañada del Refugio, in latitude 34° 27′. On the 17th they got as far as abreast the Gaviota Pass, latitude 34° 28′, where Ferrelo mentions getting large quantities of fresh sardines. If anchored just inside the kelp-field they would be in a fairly good position.

During these two days and the next Ferrelo does not mention seeing the Santa Barbara Islands; they may have been obscured by fog, for in a few days they discover San Miguel and Santa Rosa Islands. Gaviota anchorage is twelve miles east of Point Concepcion.

Vizcaino sailed through the Santa Barbara Channel without stopping, but on the main shore, two-thirds of the distance from San Buenaventura to Point Concepcion, he has made a drawing on his chart to represent "a large Indian town, adding "all this coast is wooded and free from shoals."

Monday, the sixteenth of the said month, sailing along the coast they proceeded four leagues, and anchored in the evening opposite two villages; and also this day canoes were continually coming to the ships, and they made signs that further on there were canoes much larger.

The Tuesday following, the seventeenth day of the said month, they proceeded three leagues with fair weather, and there were with the ship from daybreak many canoes, and the Captain continually gave them many presents; and all this coast where they have passed is very populous; they brought with them a large quantity of fresh sardines very good; they say that inland there are many villages and much food; these people did not eat any maize; they went clothed with skins, and wear their hair very long and tied up with cords very long and placed within the hair, and these strings have attached many small daggers of flint and wood and bone. The land is very excellent in appearance.

Wednesday, the eighteenth of the said month, they went running along the coast until ten o'clock, and saw all the coast populous, and because a fresh breeze sprung up the canoes did not come.

El Cabo de la Galera, 36½°, Cabrillo.
El Cabo de Galera, 36° "and more," Ferrelo.
La Punta de la Concepcion.

Point Concepcion, or Conception, in latitude 34° 27′; correction to Ferrelo,— 1° 33′ "and more;" to Cabrillo, — 2° 03′.

Cabrillo's description of the cape is good. It cannot be mistaken for Point Arguello, eleven miles to the northwestward. For a detailed description of this cape, and of Point Arguello, see Davidson's Coast Pilot.

Very curiously Vizcaino does not mention this remarkable headland, although he has it on his chart, but not named.

They came to a point which forms a cape like a galley, and they named it Cabo de Galera, and it is in a little over thirty and six degrees,

La Isla de San Lucas, Ferrelo. (See pp. 206, 226, 228.)
Las Islas de San Lucas, Ferrelo.

They had already seen the Island of Santa Rosa, as part of the Island of Santa Cruz when they overlapped and were named San Lucas. Now they discover San Miguel separated from the Island of Santa Rosa, which was supposed to be the western part of San Lucas.

Santa Cruz is twenty miles long, Santa Rosa fifteen miles, and the two, with the intervening passages, thirty-seven miles, or twelve leagues, which Cabrillo reckoned

and because there was a fresh northwest wind they stood off from the shore and discovered two islands, the one large, which has eight leagues of coast running east and west; the other has four leagues, and in this small one there is a good port, and they are peopled; they are ten leagues from the continent; they are called las Islas de San Lucas. From the mainland towards Cabo de Galera the shore trends west by north, and from Pueblo de las Canoas to Cabo de Galera there is a very populous province, and they call it Xexu; it has many languages

and having sailed little in several days, on account of the too fine weather, the Wednesday, of the eighteenth of the said month, they arrived at a long point, which forms a cape, and on account of its length like a galley, they named it el Cabo de la Galera; this is in thirty and six degrees and a half,

and because the wind was northwest fresh they were carried to leeward by the sea and they discovered two islands, the one of eight leagues of coast East West, and the other of four; in this they discovered a port small, very good; they found them very populous; and these people, and all those of the coast passed by, lived by fishing, and make beads from the bones of fishes, to trade with the other people of the mainland, and they are ten leagues from the Cabo de Galera: running west quarter to the northwest. During the eight days they remained

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eight leagues. San Miguel is seven and a half miles long, or two and a half leagues, whereas Cabrillo reckons it four leagues. Santa Rosa is the Isla de Cleto of Vizcaino.

From San Buenaventura to Point Concepcion the trend of the coast-line is a very little north of west, and the distance is actually twenty leagues. I suppose they propose to give only the general direction of the coast.

La Isla de la Posesion, Cabrillo.
La Isla de Posesion, Ferrelo.
Una de las Islas de San Lucas, Ferrelo.
La Isla de Baxos, Vizcaino's chart.
Ciquimuymu, Indian, Ferrelo.
San Miguel Island; the latitude of the anchorage is 34° 03′ (see p. 226). Ferrelo named the island La Isla de Juan Rodriguez after Cabrillo's death.
El Puerto de la Posesion, Cabrillo, Ferrelo.
Cuyler's Harbor. (See pp. 204, 226, 236.)

This is the largest and best harbor around the Island of San Miguel. It is a moderately large bay on the northeast face. Its extent is a little more than one mile between the eastern and the western heads, and about two-thirds of a mile deep. It has bold shores and approaches, and a large rocky islet half a mile north of the eastern head. This islet is five hundred yards in extent and 303 feet high, with a precipitous face to the north-northwest. Across the mouth of the harbor stretches a dense field of kelp having six fathoms of water throughout the greater part of it, but marked by two reefs and rocks near the middle, and almost in line between the heads. There are other rocky patches in the eastern part of the harbor.

Vessels coming into the harbor from the northwest pass within half a mile of the western head, through the kelp, at a distance of only three hundred yards from the cliffs, and then haul towards the western bight of the bay, where they anchor in five fathoms of water, over hard bottom, but protected from all save the north and east winds, which rarely blow. The heavy swell from the strong northwest winds reaches well into the anchorage. (See p. 236.)

Vessels cannot easily enter by the eastern passage unless familiar with the dangers and currents.

Water is found at one place on the steep southern hill face, and during winter water drains down the gully at the western part of the long beach southeast from the anchorage.

The summit of the island lies only a mile southward of the anchorage, and is about seven hundred feet above the sea. It is in latitude 34° 02′. There is not much vegetation upon the island, and the south and western part is swept by sand driving from the ocean beach.

The evidences are very strong of there having been a very large Indian population on this island, and doubtless the fishing was good among the kelp-fields and rocky patches off the west and northwest parts of the island.

They may have been in the broad bight between Point Concepcion and Point Arguello.

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different from each other; they have many great wars with each other; it is from El Pueblo de las Canoas to El Cabo de Galera thirty leagues; they were in these islands until the following Wednesday, because it was very stormy.

Wednesday, the twenty-fifth of the said month, they departed from the said islands, from the one which was more to the windward; it has a very good port, so that from all the storms of the sea no damage will be suffered by those within its shelter; they called it La Posesion.

This day they advanced little, as the wind was not favorable; and in the middle of the following night they had a wind, south-southwest and west-southwest, with rain, so that they saw themselves in difficulty, for it was an on-shore wind and they were near the land, and they could not double the cape on one tack or the other; and the following Thursday at vespers the wind veered to the south, and they proceeded on their course ten leagues to a

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they were well treated by the Indians, every one going naked, and they have their faces painted in the manner of a chess board; to this port they gave the name de la Posesion1

Wednesday, on the twenty-fifth, they sailed with fine weather from this Puerto de la Posesion, with wind southwest, and the following day they had it south, and southwest, with rain showers, and fog, and they had a rough time, the wind blowing on shore, being near the coast and a heavy swell running.

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The coast north of Point Arguello to San Luis Obispo Bay has a general trend north and south (true) for a distance of thirty-six miles.

Point Sal is eleven leagues from Point Concepcion, following the grand trend of the coast, and they were probably between Point Purisima and Point Sal.

Point Purisima is in latitude 34° 47′.

Point Sal is in latitude 34° 54′.

The Purisima River is in latitude 34° 42′, just north of the bold Point Arguello. (See p. 210.)

This river was certainly the Purisima, emptying just north of Point Arguello and known on the State map as the Santa Ynez. It comes through large valleys north of the Santa Ynez range, and from seaward the country has the appearance of needing a large river for drainage. Vancouver in sailing past it recorded that it seemed to give the indications of a greater river than any since he had left the Columbia.

The town of Xexo, Ferrelo.

This was at the opening of the valley lying upon the Coxo anchorage. There is water in the valley at all seasons, and some oak trees, but wood was not plenty in 1850 when we were encamped here for more than three months.

El Puerto de Todos Santos, Ferrelo.

El Coxo anchorage in latitude 34° 28′.

There can be no doubt about this port and anchorage being the same; and although Kohl says this anchorage was east of Cape Concepcion, yet he confounds it with San Luis Obispo, which is thirty-six miles to the northward.

El Pueblo de las Sardinas, Cabrillo.

Los Pueblos de las Sardinas, Ferrelo.

El Puerto de las Sardinas, 35½°, Ferrelo. (See pp. 210, 228.)

Cicacut, the Indian name, Ferrelo.

The Gaviota Anchorage off the Gaviota Pass; latitude 34° 27′; correction to Ferrelo,—1° 13′. It was at this anchorage where they got so many fresh sardines on the 17th of the month. It should be noted that it was their last anchorage before reaching Point Concepcion.

This gives us seventeen villages, including that at the Coxo, in a distance of eleven miles, exactly one village to each streamlet from the Gaviota Pass to the Coxo.

Xucu: elsewhere Ferrelo says this province of Xucu extends from San Buenaventura to Point Concepcion.

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coast running north-northwest and south-southeast; all this coast is inhabited and in appearance good land; this night they kept out to sea, for they had an on-shore wind, and the Friday and Saturday following they were beating about on one tack or the other with foul winds, and could gain nothing, and they were in thirty and six degrees and a half, ten leagues from Cabo de Galera; and in the same manner they held on during Monday and Tuesday to the thirty-first of the said month, the eve of All Saints' Day, beating about on one tack and the other; and they wished to approach the mainland in search of a great river of which they had notice, which was on the other side of the Cabo de Galera, and because there were on land many indications of rivers, and yet they found no river. Nor did they anchor here for the coast was very bold. They found during this month on this coast the weather as in Spain, from thirty-four degrees and upwards, and with much cold mornings and evenings and with storms, dark and cloudy weather, and the air heavy.

Wednesday, at midnight, on the first day of November, standing off, a strong wind from the north-northwest struck them, which did not let them carry a palm of sail, and by the dawn of day freshened so much that they could do no less than seek shelter, and they took refuge under Cabo de Galera and anchored there and went on shore, and because there was a large town which they called Xexo, and wood did not appear to be much at hand, they decided to go to Pueblo de las Sardinas, because there water and wood were very near and accessible. They called this shelter under Galera Puerto de Todos Santos.

The following Thursday they went to Pueblos de las Sardinas, where they were taking in water and wood three days, and the natives of the country aided them and brought wood and water to the ships. This village of the Puerto de las Sardinas is called Cicacut, and the others, which are from this place to Cabo de Galera, are Ciucut, Anacot, (7) Maquinanoa, Paltatre, Anacoat, Olesino, Coaacat, (8) Paltocac, Tocane, Opia, Opistopia, Nocos, Yutum, Quiman, Micoma, Garomisopona. An old Indian woman is princess of these villages, who came to the ships and slept two nights in the Captain's ship, and the same did many Indians. The village of Ciucut appeared to be the capital of the other villages, as they came there from other villages at the call of the princess; the village which is at the cape is called Xexo. From this port to Pueblo de las Canoas there is another province which they call Xucu (9); they have their houses round, and covered very well down to the ground; they go cov-

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Friday, Saturday, and Sunday on the twenty-ninth, they kept under way, with the wind from all quarters, with much difficulty.

Monday and Tuesday, of the thirty-first, they had showers and cloudy weather.

Wednesday, the first of November, at midnight, heading towards the shore they had much wind northwest, which did not allow them to carry a palm of sail, and they returned around the Cabo de la Galera, which affords good protection from this wind.

And Thursday, on the second of the same month, they were at the Pueblo de Sardinas, having sailed along forty leagues of land very well populated, and with good people; and from one village, near this port, there came the principal people aboard the ship, and they danced to the sound of a drum, and a flute of the Castilians, and they slept on board, and during these festivities they took in water, and wood, and their houses were large, with double sloping roofs, like those of New Spain, and their burying grounds were surrounded with boards: they give the name Sejo to this province: they ate acorns, hazel nuts, and fish: they said that farther on there were people with clothes on.

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Cabrillo says this province is named Sejo. The name Coxo, or Cojo, is evidently derived from these words. (See the Coxo anchorage.)

"Tamales," a well-known Spanish article of food, prepared by boiling some kind of flesh, rolled in thin sheets of dough, and wrapped in the husks of the maize. It is sold in San Francisco under the same name.

El Puerto de las Sardinas, 35⅔°, Ferrelo.

The Gaviota Anchorage is in latitude 34° 27′; correction to Ferrelo,—1° 13′. (See p. 208.)

Kohl says this harbor is to the eastward of Cape Concepcion, and yet he adds, in clear contradiction, that it "is perhaps the place now known as San Simeon," which is to the northward of Point Concepcion.

Compare with Vizcaino's description of the religious (?) ceremonies at the Great Depression of Santa Catalina Island (pp. 90–94) of the Noticia, etc.

El Rio de Nuestra Señora, Cabrillo. (See p. 208.)

The Purisima River, in latitude 34° 42′. (See Davidson's Coast Pilot for description and for the variety of names it has had.)

At the first attempt Ferrelo said ten leagues, and he was then between Point Purisima and Point Sal.

Twenty leagues beyond this position, at six leagues from the coast which they would appear to be gradually avoiding, as the southeaster was coming up.

Esteros Bay: The latitude of the haystack shaped El Morro, which is in the middle of this bay, is 35° 22′; its elevation is 573 feet, and it forms a notable landmark abreast the entrance to Morro Bay.

There is no harbor for shelter on this part of the coast from the southerly gales of winter; but there is protection from the summer winds under the northern shores of Esteros Bay, San Luis Obispo Bay, and San Simeon Bay. Vizcaino appears to have been closer in shore and to have recognized these bights.

Las Sierras de San Martin, 37½°, Cabrillo, 37½°, Ferrelo.

La Sierra de Santa Lucia, Vizcaino.

Cape San Martin, latitude 35° 54′; correction to Cabrillo and Ferrelo,—1° 36′. (See pp. 212, 224, 226.)

They were nearly abreast Las Piedras Blancas and San Simeon Bay, behind which rise the massive peaks of Rocky Butte, in latitude 35° 41′, 3,400 feet above the sea and visible at sixty-five miles; and Pine Mountain, in latitude 35° 42′, 3,500 feet above the sea and visible at sixty-six miles; they are only three miles apart. These form the southern part of the bold, compact, and unbroken line of high mountains hence to Point Pinos. It is the highest and the boldest range of coast mountains along this Pacific seaboard, reaching 6,200 feet elevation at Santa Lucia Mountain and 5,100 feet at Cone Mountain or the Twin Peaks. The former is only ten miles from the coast-line and the latter only four or five miles.

From his description he was distant about twenty-five miles, nearly south, of the present Cape San Martin, which

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ered with the skins of many kinds of animals; they eat oak acorns, and a grain which is as large as maize, and is white, of which they make tamales; it is good food. They say that inland there is much maize, and that men like us are travelling there: this port is in thirty and five degrees and two-thirds.

Monday, the sixth of the said month of November, they departed from the said port of Sardinas, and that day they made hardly any progress, and until the following Friday they held on with little wind. This day they reached Cabo de Galera; through all this course they could not make use of the Indians who came to board them with water and fish and showed much good disposition; they have in their villages their large public commons, and they have an inclosure like a circle, and around the inclosure they have many blocks of stone fastened in the ground, which project about three palms, and in the middle of the inclosures they have sticks of timber driven into the ground like masts, and very thick; and they have many pictures on these same posts, and we believe that they worship them, for when they dance they go dancing around the inclosure.

The Saturday following, the day of San Martin, on the eleventh of the said month of November, they proceeded, sailing along the land and they found themselves this morning twelve leagues from the cape, in the same place where they arrived first; and all this day they had a good wind so that they sailed along a coast, running northwest and southeast full twenty leagues; all this coast which they passed this day is a bold coast without any shelter whatever,

and there extends a cordillera of sierra along the whole of it, very lofty, and it is as high by the sea as on the land within; the sea beats upon it; they saw no population nor smokes, and all the coast, which has no shelter on the north, is uninhabited; they named the mountain las Sierras de San Martin; they are in thirty and seven degrees and a half;

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CHAPTER IV.

Which continues the discoveries of the two vessels of Don Antonio de Mendoça in the South Sea.

Saturday, on the eleventh, they were coasting, with a southeast wind and continually they were looking for el Rio de Nuestra Señora, and did not find it,

but a great range of mountains very high, with many trees, to which they gave the name Las Sierras de San Martin, and they are in thirty and seven degrees and a half,

"This fair weather enabled the ships to get away from the islands; and standing in for the continent to take a draught of the coast, they found it extremely high and mountainous,

but with some well sheltered bays, from one of which came four rush canoes." * * *

[On his chart he lays down the large bight forming Esteros Bay with the notable Morro in the middle of its length, and the entrance to Morro Bay, but he gives no name.] "Here they had a formidable gale which lasted until the 14th of December;

and the weather clearing up a little in the daytime, the ships found themselves near a very high and white ridge of mountains; but reddish towards the base, and covered with woods. This range they call the Sierra de Santa Lucia; it is the usual landfall for the China ships (p. 100)."

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is the great flanking spur or buttress for this mountain range. He was sixty miles south by east from the termination of the range at Carmel Bay, and the mountains are so high and so near the coast-line that he could have seen them if the weather permitted; but it is almost certain that he estimated his latitude and did not observe it. Even Mount Carmel, north of the Sur, is 4,417 feet above the sea and visible at a distance of seventy-five miles. It is in latitude 36° 22′ and is only eight miles inside of Point Sur. The latitude of the Twin Peaks overlooking Cape Martin is 36° 03′. The highest peak is 5,100 feet above the sea and is visible at a distance of eighty miles, and only four or five miles inshore.

We applied the name to Cape San Martin some years since to commemorate this landfall of Cabrillo.

Point Sur, or The Sur: This is a remarkable rocky looking head, rising 358 feet above the sea, and is connected with the mainland by a narrow low neck of sand dunes. See Davidson's Coast Pilot.

On his chart Vizcaino has, in this position, a slightly projecting point and the legend "Point appearing as an island."

Vancouver thought it was an island. It is in latitude 36° 18′.

El Rio del Carmelo, Vizcaino.

Carmel Bay and River, in latitude 36° 34′.

The bay of Carmel is twelve miles northwestward of the island-like point known as "The Sur." The river is a stream of minor importance, and in 1770 a mission was founded on its banks and overlooking the bay.

El Cabo de Martin, 38°, Cabrillo, Ferrelo.

El Cabo de San Martin, 37½°, Ferrelo.

La Punta de Pinos, Vizcaino (p. 101).

La Punta de los Pinos, recent charts.

Point Pinos, in latitude 36° 38′. (See pp. 210, 224, 226, 236.)

I think their Cabo de Martin, when they were driven off the coast near las Piedras Blancas, was the termination of the mountain range at or near Carmel Bay, in latitude 36° 30′. They could not have seen the pine-clad hill behind Point Pinos at the distance of sixty miles. But on the return of the expedition they explicitly state that the Cabo de San Martin which they made was in thirty-seven and a half degrees.

If we assume this later determination of his position to be the better one, the correction to Ferrelo's latitude is, —1° 00′.

On his voyage northward Cabrillo was forced by the southeast storm to leave the coast before he sighted Point Pinos, and afterwards he made the land near Fort Ross, in latitude 38° 35′.

Vizcaino's description cannot be mistaken. Except that he gives no idea of the height of the pine-covered hill lying between Carmel Bay and Monterey Bay, it describes the point and applies to no other.

El Puerto de Monte-Rey, Vizcaino.

Monterey Harbor, in latitude 36° 31′.

This harbor is well protected from the southeast storms which were those most destructive to the early navigators, and therefore Vizcaino extolled it far beyond its real merits and thus misled Constanzo and others in 1769.

the spurs of these and of the sierras on the northwest form a cape which projects into the sea in thirty and eight degrees; they named it Cabo de Martin.

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and at the termination of them, at the northwest, it forms a cape which is in thirty and eight degrees, and they named it Cape Martin.

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(P. 100.) "Four leagues farther a river enters into the sea between some rocks, after a precipitate course from some high and white mountains; the banks of this stream are covered with black and white poplars, willows, and other trees and brambles known in Spain. This river is called del Carmelo.

"Two leagues farther northward of the river Carmelo there is a famous port, and between this and the river there is a forest of pine trees two leagues in extent, and there is a point of land at the entrance to the harbor that is called Punta de Pinos (p. 100).

(P. 101.) "On the 16th of December the squadron put into this port which was called de Monte-Rey (in honor of Don Antonio de Mendoza, the Count of Monte-Rey, Viceroy of New Spain; by whom they had been sent on this Discovery, in the name of his Majesty). * * *

(P. 107.) "This is a very good harbor, and affords good

Although open to the northwest winds they do not blow home with great force.

Vizcaino applied the name only to the southeast angle of the bay where the town of Monterey is situated. This is evident from his outline chart, although he has the general features to the north and northwestward. For a detailed description of the harbor and bay see Davidson's Coast Pilot.

Point Año Nuevo, latitude 37° 06′.

Vizcaino has no reference to this low point or to the massive spur behind it in his narative; and no name on his chart, although there is a point faintly indicated in this locality. (See p. 224; Black Mountain.)

Half Moon Bay, latitude 37° 30′.

The indication of this bay is very clear on the chart of Vizcaino, but there is no name given to it, and no reference made to it in the narrative. The general trend of the coast is good. North of Half Moon Bay, Vizcaino's chart says, "the coast is wooded," which is one of its characteristics for a very short distance.

La Baia de Pinos, Cabrillo.

La Bahia de los Pinos, Ferrelo; latitude 39° and a "little more."

La Ensenada de los Farallones, later Spanish authority.

The Gulf of the Farallones of the U. S. Coast and Geodetic Survey. (See p. 222.)

Correction to Ferrelo,—1° 00′ and a "little more."

This gulf, extending from Point San Pedro, in latitude 37° 35′, to Point Reyes, in latitude 38° 00′, and embracing the Farallones de los Frayles, was seen by Cabrillo and Ferrelo, as is shown by their narratives, on their first return from the northward, Friday, the 16th of November, 1542.

Whether they intended the name to include this great bight is doubtful, although Cabrillo called it a "great gulf," but this may mean only the bight between Point Reyes and Ballenas Point. There are no pines south of those which are on the ridges near Mount Tamalpais* until we reach Point San Pedro and then they are sparse until the crest-line is reached about latitude 37° 25′.

Portus Novæ Albionis, Drake, 38° and 38° 30′.

El Puerto de San Francisco, Vizcaino.

Sir Francis Drake's Bay.

Drake's Bay, latitude 38° 00′.

Drake's Bay is a capital harbor in northwest winds, such as Drake encountered. It is easily entered, sheltered by high lands, and a vessel may anchor in three fathoms close under the shore in good holding ground. Drake's vessel drew thirteen feet of water "to make her swim," and it would appear that when she was leaking he moved her to the beach and careened her.

If he had been inside the Estero Limantour, of which he could not have detected the entrance from his vessel, he would necessarily have been very close to either shore. And had he seen it he would not have dared to enter it without sounding it out. It has only thirteen feet of water on the bar at the highest tides, and he would not have hazarded his vessel in entering such a doubtful anchorage. Nor would he have risked the pos-

* Tamal pais, the country of the Tamal Indians. The Table Mountain of Beechey.

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protection, and is sheltered from all winds. It has extensive forests, and an infinite number of very great pines, straight and smooth, fit for masts and yards; likewise evergreen oaks of a prodigious size proper for building ships. Here also are rose-trees, white thorns, firs, willows, and poplars; large clear lakes, fine pastures, and arable lands. * * * The sea abounds with oysters, lobsters, crabs, etc. Also huge sea wolves and whales. This harbor is surrounded with rancherias of indians, a well-looking affable people; * * * who expressed great concern when the Captain and tender sailed out of this harbor on the third of January, 1603, * * * in search of the Cabo Mendocino.

"Hero" (p. 116).

"They were forcibly carried southward from forty-eight to thirty-eight degrees, where they found the land low and plain, with some few hills covered with Snow. June 17th, [1579,] (p. 117) they came to a convenient harbour and continued there till July 23rd, during which, though in the height of Summer, yet they had constant nipping Cold (neither for fourteen days could they see the Sun for the fogginess of the Air), * * * the Trees being without Leaves, and the Ground without Grass, even in June and July: * * * Tho' the real Cause of this Extremity is uncertain, yet it is judged to proceed from the large Continent of America and Asia, near together, northward of this place, from whose high Mountains, always covered with Snow, the North-West Winds, which usually blow on those Coasts, bring this almost unsufferable sharpness, which the Sun in his greatest Heat is not able to dissolve, from whence the Earth is so barren, and the Snow lies at their Doors almost in the midst of Summer, but is never off their Hills, from whence proceeded those stinking Fogs through which the Sun cannot pierce, nor draw the Vapors higher into the Air, ex-

"The Capitana and Fragata had no sooner left the harbor of Monterey to seek for the Cabo de Mendocino, than they had a formidable wind which lasted to the sixth of January, the day of the Los [Santos] Reyes, and carried them beyond the Puerto de San Francisco. And the day after that of Los Reyes, which was the 7th of January, the wind suddenly shifted to the northwest and blew somewhat fiercely, but they were able to make some headway; and the Fragata concluding there was no necessity to seek a harbor from this wind continued her voyage; and the Capitana thinking they were in company did not show a light; so in the morning they were not in sight of each other, and the General returned with the Capitana to the Puerto de San Francisco to wait for the Fragata; but they did not hear of her until they returned to Mexico. Another reason which prompted the Capitana to put into Puerto de San Francisco, was to make a reconnaissance of it, and learn if anything was to be found of the ship San Augustin, which came upon the coast in 1595, * * * under the Pilot Sebastian Rodriguez Cermeñon; and being in this port she was

sibility of attack from the Indians in such a contracted place. He doubtless anchored in Drake's Bay, and the reef in his plan represents in a crude manner the reef off the easternmost point of Point Reyes Head. In a rough sketch of his anchorage it is called Portus Novæ Albionis.

The "World Encompassed" describes Drake leaving the coast in latitude 43° and going southward, as follows: "And he drew backe againe without landing, til we came within thirtie-eight degrees towards the line. In which height, it pleased God to send us into a faire and good bay, with a good wind to enter the same."

In the "Hero" the narrator says:

"From the height of 48 degrees, in which now we were, to 38, we found the land, by coasting alongst it, to bee but low and reasonable plaine; every hill (whereof we saw many, but none verie high), though it were in June, and the Sunne in his nearest approach onto them, being covered with snow.

"In 38 degrees 30 minutes, we fell in with a convenient and fit harborough, and June 17th came to an anchor therein." * * *

Continuing in the "World Encompassed," the narrator writes:

"In this bay we ankered the seventeenth of June, and the peo p of the Countery, having their houses close by the water's side, shewed themselves unto us, and sent a present to our Generall. * * * Our Generall called this countery *Nova Albion*, and that for two causes: the one, in respect of the white bankes and cliffes, which ly towardes the sea; and the other, because it might have some affinitie with our countrey in name, which sometime was so called.

"There is no part of earth here to bee taken up, wherein there is not some speciall likelihood of gold or silver.

"At our departure hence our Generall set up a monument to our being there." * * *

From a recent visit to Drake's Bay (1886), we feel assured he was anchored close under the point. From this place he could not see any fair indication of there being a lagoon like the Estero de Limantour. Moreover, that he was not in that estero would appear by the following precautions he took against any surprise by the natives:

"The third day following, viz, the 21st, our ship having received a leake at sea, was brought to anchor neerer the shore, that, her goods being landed, she might be repaired; but for that we were to preuent any danger that might chance against our safety, our Generall first of all landed his men, with all necessary promission, to build tents and make a fort for the defence of our selves and goods; and that wee might vnder the shelter of it with more safety (what ever should befal) end our business" (p. 122). "When they [the Indians] came to the top of hill, at the bottom whereof wee had built our fort, they made a stand." * * *

On the sketch of Portus Novæ Albionis there is the legend, "Fæda corporum laceraetione et crebris in montibus sacrifiesis hujeis Novi Albionis portus incolæ Drecis jambis coronoto decesium deflent."

(By horrible lacerations of their bodies and by frequent sacrifices in the mountains, the inhabitants of this

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cept the fierce Winds do sometimes scatter them; and when gone, the Fogs return as before."

Chap. VI., p. 118. * * *

"Next day after their coming to Anchor in the harbour afore-mentioned, the Natives of the Country discovering them, sent a Man to them in a Canoe, with all Expedition. * * * *June* 23, their Ship being leaky, came nearer the shore to Land their Goods; but to prevent any surprize, the General sent his Men ashore first with all necessaries for making Tents, and a Fort for securing their Purchase; * * * their Houses are dug round within the Earth, and have from the surface to the Ground, Poles of Wood set up and joined together at the Top like a Spired Steeple, which being covered with Earth, no water can enter (p. 120), and are very warm, the Door being also the Chimney to let out the Smoke, which are made Slopous, like the Scuttle of a Ship * * * (p. 121). The General having experienced the treachery of other Infidels, provided against any Alteration of their mind, setting up Tents, and intrenching themselves with Stone Walls; which done they grew more Secure. * * * The Indians * * * coming to the Top of the Hill, at the Bottom whereof they had built their Fort, they made a stand, where their chief speaker wearied himself, and them with a long oration, &c. (p. 123), their Hioh or King appeared. * * *

(P. 128). "Having finished their Affairs the General and some of his Company made a Journey up into the Country, to observe their manner of Living, with the Nature and Commodities of the Country; * * * the Inland was far different from the Seashore, it being a very fruitful soil, furnished with all Necessaries, and stored with large fat Deer, whereof they saw Thousands in an Herd, &c. * * *

"This Country General Drake called Nova Albion, both because it had white Cliffs towards the Sea, and that its Name might have some likeness to England, which was formerly so called. Before they went hence, the General caused a Monument to be erected, signifying the English had been there, and asserted the Rights of Queen Elizabeth and her Successors to that Kingdom, all engraven in a Plate of Brass, and Nail'd to a great firm Post, with the Time of their Arrival, the Queen's Name, and the free Resignation of the Country by the King and People into her Hands; likewise her Picture and Arms, and underneath the General's Arms. * * *

"July the 23rd, they [the Indians] took a sorrowful leave of them, but loth to part with them, they went to the top of the Hills to keep sight of them as long as possible, making Fires before, behind, and at each side of them, therein they supposed Sacrifices were offered to their happy Voyage."

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wrecked and driven on shore by a contrary wind; and among those who were there at that occurrence was the chief pilot.

port of New Albion deplore the departure of Drake now twice crowned.)

Among the Nicasio Indians of the Nicasio Valley, lying to the eastward of Drake's Bay, there is said to be a tradition that Drake anchored in this bay; that some of his crew deserted and lived among the Indians; and that he gave the natives some seeds, and among other things some hard ship-biscuit, which they innocently planted. He also left among them a sow and a boar; and the early Spaniards report that when they came to this region the country was filled with wild hogs.

Ballenas Bay: To the southward of Drake's Bay, and nearly half way to San Francisco Bay entrance, there is a small cove somewhat protected by a reef from the northwest swell. The name Volanos or Bolanos, Vizcaino's pilot, at once suggests the origin of the present name *i. e.*, the Bay of Bolanos.

La Punta de los Reyes, Vizcaino.

Point Reyes, latitude 38° 00′.

The chart of Vizcaino gives a fair idea of Point Reyes and its relation to Drake's Bay, but the latter is exaggerated. He has an entrance to a large estero now known as the Estero de Limantour, or Drake's Lagoon.

For a detailed description of this remarkable headland, which forms the northern boundary of the Gulf of the Farallones, see Davidson's Coast Pilot.

The Isles of St. James, Drake.

Los Frayles, Vizcaino's chart.

Los Farallones de los Frayles of the later Spanish navigators.

The North Farallones, the Middle Farallon, and Southeast Farallon, latitude 37° 42′.

It is a curious fact that neither Cabrillo nor Ferrelo mention these notable islets, although they describe and name the great gulf under Point Reyes Head. Drake's description admits of no doubt whatever. Vizcaino does not mention this extensive group of high islets in his narrative, but has five "Frayles" laid down off his port of San Francisco, doubtless the North Farallones, and a large islet close inshore and to the southward. This latter is certainly the largest and highest, or the Southeast Farallon, and it would appear that he did not sail between it and the shore, because he has laid it down dangerously near to the coast.

This remarkable group of islands forms a notable feature in the navigation of this part of the coast. The Southeast Farallon is a high rocky islet about one mile in extent, rising abruptly from deep water, with several well-defined heads, one of which attains an elevation oi 360 feet This islet may sometimes have been mistaken for several islets close together. It lies in latitude 37° 42′, twenty-four miles broad off the Golden Gate, and eighteen miles true south of Point Reyes Head. It is a wild granitic mass of rock, without a particle of soil, and the resort and breeding-place of thousands of sea-lions and millions of sea birds. There are two or three landing places around the island.

Francisco de Volaños, who was with the present expedition. He recognized the place and affirmed that they had left on shore a great quantity of wax, and chests of silks, and the General was anxious to discover some vestiges of these.

"The Capitana came to anchor behind a point of land which makes this port [Puerto de San Francisco, *i. e.* Drake's Bay], and which he called La Punta de los Reyes; but no one was sent ashore that they might be in readiness for the tender; and on the day following, the Capitana sailed out in search for her. The wind was northwest and light and the Capitana moved slowly. * * *

"A little without their Harbour lye certain Isles, and by them the Islands of St. James, wherein are plenty of Seals and Fowls, and Landing on one of them the next day, they supplied themselves with competent Provision for some time (Hero, p. 129).

"The 23 of *July* they took a sorrowfull farewell of vs but being loath to leave vs, they presently runne to the top of the hils to keepe vs in sight as long as they could, making fires. * * *

"Not farre without this harborough did lye certain Islands (we call them the Islands of Saint *James*), having on them plentifull and great store of Seales and birds, with one of which wee fell *July* 24, whereon we found such provision as might competently serue our turne for a while. We departed againe the day next following, viz, *July* 25." (World Encompassed, p. 134.)

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The North Farallones is a group of four smaller islets and low rocks gathered together in a somewhat compact body. The four principal islets are high, barren, and almost inaccessible. The highest rises to an elevation of 158 feet. The group lies six and three-fifths miles northwest by west from the Southeast Farallon, and twelve miles south-southwest from the western extremity of Point Reyes Head.

The depth of water around these islands is thirty fathoms, and the same continues well in towards the shore so that it is somewhat strange that Cabrillo, Ferrelo, and Vizcaino did not go inside of them; they could not have been coasting very closely along the main shore.

Frequently these islets are hidden by the fogs even when the shores are fairly free and visible.

Rio Grande de San Sebastian, Vizcaino's chart.

Tomales Bay:

The mouth of Tomales Bay is in latitude 38° 14'.

This body of water is shown on Vizcaino's chart but no mention is made of it in the narrative. It is indicated in the locality of Bodega Bay, six leagues north of Point Reyes, by a large river leading many leagues to the eastward. It might be considered the Estero Americano, but this stream is quite narrow, not straight, and is not easily made out from seaward. It is almost certainly Tomales Bay, which would show the mile-wide entrance between the ridge of Tomales Peninsula and the equally high land forming the eastern shore of the bay.

Tomales Bay is ten miles long with a navigable channel a good distance in. But the bar at the entrance is generally marked by breakers, and has less than ten feet of water upon it at low tide.

On old Spanish charts we find the name sometimes spelled Tamales; and it would seem a reasonable conclusion that it was named after the Tamal Indians.

The vessels of Cabrillo were compelled by stress of weather to leave the coast when near Cape San Martin. From his description I place him about twenty-five miles nearly south of the present Cape San Martin, which is the great flanking spur from the mountains of the Santa Lucia range. He was sixty miles south by east from the termination of the range at Carmel Bay, and the mountains are so high that he may possibly have seen them; but it is more probable that he estimated his distance, and also that the range was cloud-capped.

In the heavy "southeaster" it is evident that their small vessels were very seriously in danger, and that for safety each had to look out for itself.

A rough plotting of their courses clearly indicates that they were far away from the coast.

"Echaron un Romero" means that they cast lots to decide who should go on the pilgrimage to the church and make the offering to Our Lady Guadalupe. A marginal note in Herrera states: "Voto de los Marineros de la Nao de D. Antonio de Mendoça, à Nuestra Señora del Rosero."

They sight land to the northward of the Slavianski or Russian River on the 14th; the summit of Ross Mountain is over 2,200 feet above the sea and only three miles from the shore. It is in latitude 38° 30', and is visible from the latitude of Point Reyes.

FERRELO

This same night of Saturday, at four o'clock in the night, being in the sea about six leagues from the coast, lying to waiting for the day, with a southeast wind, so great a storm struck them from the southwest and the south-southwest with rain and dark cloudy weather, that they could not keep up a handbreadth of sail, and it made them scud with a small foresail, with much labor, all the night, and the Sunday following the tempest broke upon them with much greater violence, which continued that day and night until the following Monday at noon, and the storm was as great as can be experienced in Spain. On Saturday night they lost sight of their consort.

Monday, the thirteenth of the said month of November, at the hour of Vespers, the weather cleared up and the wind veered to the west, and immediately they made sail and went in search of their consort steering towards the land, praying to God that they might discover her, as they much feared that she would be lost; they were running to the north and to the north-northwest; with the wind west and west-northwest; and the following Tuesday at daybreak they had sight of the land, and they were able to hold on until the evening, and they could see that the land was very high, and they cruised along the coast to see if there was any port where they might take shelter; and so great was the swell of the sea that it was fearful to behold; and the coast was bold, and the

and at four hours in the night, commencing to blow strongly the wind from the south-southeast, and from the southwest, with showers, and heavy clouds, and a great sea that nearly engulfed them, and at dawn, it blowing tremendously, it was not possible to run, except with the least amount of sail, before the wind, and on account of the strong sea, wind, and dense clouds, one vessel lost sight of the other, and that one vessel threw overboard everything that could lighten her, from the deck, because the storm was very great; and on the Capitana, seeing themselves in the greatest danger, they vowed a pilgrim-

age [echaron un Romero] to our Lady of the Rosary and the blessed Mother of Pity, for her mercy, and she favored them with a little fair weather. And Monday, on the thirteenth of said month, they were heading towards the land, in search of the other vessel, and during the night they kept a lookout, in order not to lose sight of anything, and to search for some shelter, and to make the land.

DAVIDSON.

Cabo de Pinos, Cabrillo, 40° "and more."

Northwest Cape, Russian. (See pp. 224, 228, 236.)

This is the bold high spur of the coast mountains nearly overhanging Fort Ross Cove, in latitude 38° 31′. This gives a correction to Cabrillo and Ferrelo of,—1° 29′.

The vessels were not near enough to the coast to see the details of the shore-line.

This bold shoulder with the forests upon it was the distinguishing mark for the Russian ships when making the small harbor of Fort Ross. The massive character of the orography is well exhibited in the latest editions of the Coast Survey charts.

Cabrillo's description is good, even to the direction of the coast-line.

The Russian name "Northwest Cape" was not really applied to the cape above described, but to the comparatively low rocky point at the northwest part of the Fort Ross Cove. (See Davidson's Coast Pilot.)

Punta de Arena.

Point Arena, latitude 38° 57′.

This point lies thirty-seven miles northwest, along a straight coast-line, from the Northwest Cape at Fort Ross Cove; and Cabrillo could not have seen the point itself when he was in his latitude of Cabo de Pinos. But he could have readily made out the high mountains lying seven or eight miles southeast of Point Arena and bordering the coast. Moreover, if he sailed along the shore beyond Cabo de Pinos before the gale struck him (as they apparently got observations of the sun at noon), he may have actually seen Point Arena. As he had seen no point with such marked peculiarities it is strange he did not describe it. The long terrace land stretches out three miles from the base of the mountains and terminates in vertical cliffs from two hundred and sixty feet to forty and fifty feet in height, with whitish faces in the sunlight.

Cabrillo's Friday is an error, as shown by the context; it should be Thursday.

Baia de Pinos, Cabrillo.

La Bahia de los Pinos, Ferrelo, 39° and "more."

Ensenada de los Frayles.

The Gulf of the Farallones.

Drake's Bay, latitude 38° 00′; correction to Ferrelo, —1° 00′ and "more." (See p. 214.)

The "Great Gulf" of Cabrillo may possibly be intended to embrace the bight from Point Reyes Head to Point Boneta, or even to Point San Pedro. It could not have been intended for Bodega Bay, because this has no characteristics of a great gulf, and there have been no pines upon Bodega Head, Point Tomales, or the eastern shore of the bay since its occupation in the last fifty years; nor is there any indication of such a growth previously. On the other hand, a part of the ridges and all the gulches from Mount Tamalpais are even yet forest clad. This is quite a marked feature from seaward. Moreover, the reported latitude carries the location to the Gulf of the Farallones.

FERRELO.

mountains very lofty, and at evening they lay to for rest; it is a coast running northwest to southeast; they perceived the land at a point which projects into the Ocean, which forms a cape, and the point is covered with trees, and it is in forty degrees.

Wednesday, the fifteenth day of the said month, they had sight of their consort, for which they gave many thanks to God, as they had considered her lost; and they came up with her and joined her at evening. They of the other ship endured more danger and risk than those of the Captain's vessel, on account of its being small and having no deck. This land where they were sailing is to appearance very good, but they saw no Indians nor smokes. There are grand Sierras covered with snow; there are many trees. At night they lowered the sails and lay to.

On the following Thursday, the sixteenth of the said month of November, at daybreak, they were upon a large gulf which was formed by a change of direction of the shore, which appeared to have a port and a river, and they went beating about this day and the night and the Friday following, until they saw that there was no river nor any shelter; and to take possession they cast anchor in forty-five fathoms. They did not dare to land on account of the high sea. This gulf is in thirty and nine degrees and more, and it is all covered with pines to the sea. They gave it the name of La Bahia de las Pinos. The following night they lay to until the next day.

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There is a Cape, projecting into the sea, very much wooded, with very high pine trees, and they called it Cabo de Pinos, and observing the Sun, they found themselves in forty degrees, and more, to the northwest,

from whence they recognized more than fifteen leagues of coast, all the land high, and the coast running from northwest southeast:

And Friday, the sixteenth, they arrived at a Great Gulf, that looked like a harbor, and they called it Pinos.

DAVIDSON.

El Cabo de San Martin. (See pp. 210, 222, 226, 236.)

This is either the northern limit of the Sierra Santa Lucia near Point Carmel or the San Martin which they made in the early part of the voyage when they were storm struck and had to run before it. The former would probably be the more likely, because on the 18th they were running from near Point Reyes all day along the coast, and passing the deep bight of Monterey Bay would make the pine-covered mountain behind Point Pinos or the higher mountains beyond Point Carmel by nightfall.

FERRELO.

The following Saturday they were running along the coast, and they found themselves at night off El Cabo de San Martin.

DAVIDSON.

It is evident that Ferrelo runs ahead in his narrative to describe in general terms the appearance of the coast range of mountains from the Gulf of the Farallones to Cape San Martin, and then returns to take up the details. His Sierras Nevadas form the mountain range of the Peninsula of San Francisco, in whose crest-line is Loma Prieta reaching an elevation of nearly 3,000 feet, and which is about thirteen miles inside of Point Año Nuevo lying under his Snowy Cape. Mount Bache, in the same range, is in latitude 37° 06¼′ and reaches 3,825 feet elevation. His description is good, although it would apply with greater force to the stupendous barrier of the seaward face of the Sierra Santa Lucia; he may very probably have had both mountain ranges in his mind at the time of compiling his narrative.

FERRELO.

All the coast they passed by this day is very bold, and there is a great swell of the sea, and the land is very lofty; there are mountains which rise to the sky and the sea beats upon them. While sailing near the land it appears as if they would fall upon the ships; they are covered with snow to the summit.

DAVIDSON.

Las Sierras Nevadas, Ferrelo.
La Sierra de Santa Cruz.
The Peninsula of San Francisco.
Cabo de Nieve, Ferrelo, 38⅔°.
Cabo de Nieve, Cabrillo, 38⅔°.
Black Mountain, latitude 37° 09′.

This is the massive western spur or buttress of the San Francisco Peninsula Mountains immediately behind and almost overhanging the low Point Año Nuevo. The ships were not close enough to the coast for Cabrillo to note the details of the shore-line, but he took in the broad, bold features, and graphically describes them under the aspect of a heavy winter. I place this great shoulder of the range in latitude 37° 09′, whence the correction to Ferrelo and Cabrillo is,—1° 31′.

Mount Bache, reaching 3,825 feet elevation, is in latitude 37° 06¼′.

FERRELO.

They gave them the name of las Sierras Nevadas, and the principal one forms a cape which projects into the sea, which they named Cabo de Nieve. The coast runs north-northwest and south-southeast. It does not appear that Indians inhabit this coast. This Cabo de Nieve is in thirty and eight degrees and two-thirds, and always when the wind blew from the northwest it made the weather fair and clear.

DAVIDSON.

Ferrelo again runs ahead of events in his narrative in mentioning his approach to the Santa Barbara Islands and then returns and describes the coast from Cabo de Pinos (Northwest Cape at Fort Ross). (See pp. 210, 222, 226, 236.)

By plotting his course as far as practicable during the storm and his again making the coast, I fix his approach thereto south of Point Arena, at the cape he describes, but even then he must have been twenty-five miles from the coast-line.

He could not have followed the shore very closely or he would have seen the bays of Esteros, San Luis Obispo, and Point Sal. Moreover the coast was thickly populated from the San Carpofero to Point Concepcion; and from Carmel Bay northward the coast was also thickly inhabited.

FERRELO.

Thursday, on the twenty-third day of the month, they approached on a return course the islands of San Lucas, and one of them named la Posesion; and they ran along all the coast, point by point, from el Cabo de Pinos to them, and they found no shelter, so that of necessity they had to return to the said island, on account of having these days a very strong west-northwest wind, and the swell of the sea was very great. From Cabo de San Martin to Cabo de Pinos we saw no Indians, because of the coast being bold and without shelter and rugged; and on the southeast side of Cabo de Martin for fifteen leagues they found the country inhabited, and many smokes, for the land is good; but from el Cabo de Martin as far as to forty degrees we saw no signs of Indians.

CABRILLO.

ULLOA AND VIZCAINO.

And on the eighteenth they were seeking for a port,

and discovered some snow covered sierras, with a cape, which projected therefrom, which they called Cabo de Nieve, in thirty and eight degrees and two-thirds, and the whole land and coast, possesses this peculiarity, that, whenever the wind blows from the northwest, the weather is all clear, without any scud or anything else; and from the thirty and seven degrees and a half, hence to the forty degrees, this coast runs northwest southeast;

DAVIDSON.

El Cabo de San Martin, Ferrelo, 37½°. (See pp. 210, 222, 224, 236.)

The present Cape San Martin is in latitude 35° 54′, but Mount Carmel, one of the high peaks of the Sierra Santa Lucia (Ferrelo's Sierra San Martin) would probably be the first mountain he would see when approaching from the north across the Gulf of Monterey. In the clear sky of northwest weather he would have seen it when he was abreast of his Cabo de Nieve, or Point Año Nuevo. It is in latitude 36° 22′, rises to an elevation of 4,417 feet, and is visible at a distance of seventy-five miles. It is only eight miles inside of Point Sur.

La Isla de la Posesion, Cabrillo.

Una de las Islas de San Lucas, Cabrillo.

Isla de Posesion, Ferrelo.

La Isla de Juan Rodriguez, Ferrelo.

Ciquimuymu, Indian, Ferrelo.

La Isla de Baxos, Vizcaino.

San Miguel Island. (See pp. 204, 206, 236.)

This is the westernmost of the Santa Barbara Islands. (For a detailed description see Davidson's Coast Pilot of California, &c.)

El Puerto de la Posesion, Cabrillo.

This is Cuyler's Harbor in latitude 34° 03′, already described. (See p. 236.)

The "other islands of San Lucas" is San Salvador, Ferrelo. (See p. 204.)

Limun or Limu, Indian, Ferrelo.

Santa Cruz Island, already described. (For a minute description of the island see Davidson's Coast Pilot of California, &c.)

He apparently forgets that Cabrillo named Santa Catalina Island San Salvador, and he slightly changes the spelling of the Indian name.

FERRELO.

El Cabo de San Martin is in thirty and seven degrees and a half.

While wintering in this Isla de Posesion, on the third day of January, 1543, departed from this present life Juan Rodriguez Cabrillo, Captain of the said ships, from a fall which he had on the same island at the former time when they were there, by which he broke an arm near the shoulder. He left for Captain the Chief Pilot, who was one Bartolomè Ferrelo, a native of the Levant; and he charged them much at the time of his death that they should not give up the discovery, as far as possible, of all that coast. They named the island La Isla de Juan Rodriguez. The Indians call this island Ciquimuymu, and another they call Nicalque, and the other they call Limu. In this island de la Posesion, there are two villages; the one is called Zaco (10) and the other Nimollollo. On one of the other islands there are three villages; one they call Nichochi, and another Coycoy, and the other Estocoloco. On the other island there are eight villages, which are, Miquesesquelua, Poele, Pisqueno, Pualnacatup, Patiquiu, Patiquilid, Ninumu, Muoc, Pilidquay, Lilibeque.

The Indians of these islands are very poor. They are fishermen; they eat nothing but fish; they sleep on the ground; all their business and employment is to fish. In each house they say there are fifty souls. They live very swinishly; they go naked. They were in these islands from the twenty-third of November to the nineteenth of January. In all this time, which was almost two months, there were very hard wintry storms on the land and the sea. The winds which prevailed most were west-southwest and south-southwest and west-northwest. The weather was very tempestuous.

Friday, the nineteenth day of the month of January, 1543, they set sail from the island of Juan Rodriguez, which is called Ciquimuymu by the natives, to go to the mainland in search of some supplies of provisions for their voyage, and in leaving the port a heavy storm from the west-northwest struck them, which made them put into the other islands of San Lucas, and they anchored off the island of Limun, to which they gave the name of San Salvador, and they found it necessary to weigh anchor again because it had no port more under the shelter of the islands, and the wind veered around from all points, and they sailed around these islands eight days with the wind very foul, sheltering themselves under the islands from the bad weather; and on the twenty-seventh of the said month they entered the same port of the island of Juan Rodriguez where they were before. The greatest hindrance they had was because the winds were not steady, but went veering about from one point to another. Those which are the more constant are from the west-northwest and from the west-southwest.

and because they did not find any port, they had to go to la Isla de la Posesion, which is one of the Islands of San Lucas, and they entered there Thursday, on the twenty-third of November, and because it is a good port, they repaired the small vessel, and made her staunch, as she was going to sink.

In the aforesaid port they remained, until the end of December, on account of the bad weather, with great cold and snow, even to the sea level, rain from heaven, and heavy clouds; and as the southeast storm was continuing, there was so great a surf, although in a land-locked harbor, that sometimes for three and four days, it was not possible to go on shore. Finally, Friday, on the nineteenth of January of the following year, one thousand five hundred and forty-three, with great labor they arrived at the Puerto de Sardinas,

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La Isla de San Sebastian, Ferrelo's consort. (See pp. 204, 236.)

La Isla de San Lucas, Ferrelo.

La Isla de Cleto, Vizcaino's chart.

Nicalque, Indian, Ferrelo.

Santa Rosa Island, lying between San Miguel Island and Santa Cruz Island.

He probably lost his anchor in Becher's Bay on the northeast face of the island, where he could have watered his vessel.

For minute description of the island see Davidson's Coast Pilot.

El Puerto de las Sardinas, Ferrelo.

Cicacut, Indian, Ferrelo.

The Gaviota anchorage. (See pp. 208, 210.)

In the Gaviota Pass there are evidences of large Indian Rancherias, where the Indians could retire from the coast-line in winter and thus avoid the full effects of the storms, and at the same time engage in hunting or cultivate the ground.

La Isla de San Salvador, Ferrelo.

Santa Cruz Island. (See pp. 204, 236, 238.)

If we suppose that he ran nearly south, and half way between Santa Cruz and San Nicolas, he would probably have seen the islands of San Miguel, Santa Rosa, Santa Cruz, Anacapa, Santa Catalina (with Santa Barbara in line and not distinguishable), and San Nicolas. He could not have seen San Clemente Island; Anacapa is small; and Santa Catalina would, at that distance, appear small. San Nicolas would be seen moderately small, because he would make it endwise.

When the unusual northeast wind changed and the west-northwest wind came up with the large sea always accompanying it, it is very unlikely that he was even two hundred miles to the windward of the islands. And yet we find Kohl making the unaccountable blunder of supposing that the six islands which Ferrelo saw "were doubtless the Sandwich Islands"!

El Cabo de Pinos, Ferrelo.

Already described as the mountain mass behind Fort Ross Cove. (See pp. 210, 222, 224, 236.)

This is the Punta de Arena in latitude 38° 57′, but he does not name it; the land trends to the northwestward from Bodega to this point, then the shore changes its direction to north-northwest.

El Cabo de Fortunas, Cabrillo, 41°.

They saw the great mountain mass which reaches a height of nearly 4,300 feet a little to the northward of

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Tuesday, the twenty-ninth of the said month of January, they departed from the island of Juan Rodriguez for the island of San Lucas, which is in the middle of the others, to take up certain anchors which they had left in a storm, not being able to raise them; and which they recovered, and took in water.

They departed from this island of San Lucas Monday, the twelfth day of the month of February, which they could not do sooner on account of the bad weather, which gave them winds and much snow. It is inhabited, and the people are like those of the other island. The Indians call it Nicalque. There are three villages on it, which are called Nicochi, Coycoy, Coloco.

This day they went to Puerto de las Sardinas, to take in wood and other things necessary for their voyage, as they were not to be obtained on those islands.

Wednesday, on the fourteenth of the said month, they departed from El Puerto de Sardinas, having taken a boat-load of wood, and they did not dare to remain longer there on account of the great swell of the ocean; they did not find so many Indians as before, nor any fishing on account of the winter; the natives eat oak acorns and other seeds and herbs of the field without cooking. From this place they proceeded to the island of San Salvador, because they were there more secure from the storms, that they might be able to make sail and run out to sea.

Sunday, the eighteenth day of the said month of February, they departed from the island of San Salvador with a moderate wind from northeast, and they ran along to the southwest, because they had been told that there were other islands toward the southwest; they were at dusk this day about twelve leagues from the island of San Salvador, and they saw six islands, some large and others small.

This day a sailor died, and the following Monday, at daybreak, they were at sea about ten leagues to the windward of the islands, and with the wind west-northwest they were standing off five days to the southwest, and after they had proceeded about one hundred leagues they found the wind more violent and the sea high;

and Thursday, the twenty-second of the said month of February, they again stood in shore to endeavor to reach Cabo de Pinos, with the wind south-southeast, which continued three days, and was increasing each day; and the Sunday following, at daybreak, they gained sight of Cabo de Pinos, and they were this day at dusk twenty leagues to windward on a coast running northwest and southeast, and it is bold and without shelter; there was no smoke seen on the land, and they saw a point which formed the extremity of the land, which changed the coast to the northwest; in the middle of the night the wind suddenly shifted to the south-southwest, and they ran to the west-northwest until day, and in the morning the wind shifted to the west-southwest with great violence, which held on until the following Tuesday; they ran to the northwest.

whence they left on the fourteenth of February.

And Monday, on the twenty-sixth ot saia montn, tney were at a point which makes a cape, which they called Cabo de Fortunas, on account of the many dangers which they had experienced in those days, and it is in forty and one degrees:

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Point Delgada at Shelter Cove; and continues as a bold range to the north of Cape Mendocino. They could not have seen Point Delgada because it is low and projected on the base of the coast mountains. If he saw King Peak, or the mountain behind Cape Gorda, or Mount Pierce behind Cape Mendocino, then his latitude must be assumed to have been derived from dead reckoning. Cape Mendocino is in 40° 27′, Cape Gorda in 40° 13′, but the high crest-line of the mountains runs to the south of 40°. This course from Point Arena is nearly north-northwest, true.

Vizcaino's two ships had been separated in a storm, and the crews were in a terribly bad condition from scurvy.

These are the high mountains lying eastwardly from Point Delgada, and culminating in King Peak in latitude 40° 09′, at an elevation of 4,265 feet.

Cabo Mendocino, Vizcaino's pilots, 41°, without observation.

Cape Mendocino, latitude 40° 27′.

The description and the position of the cape in relation to the foregoing mountains are good for Cape Mendocino, but I think the latitude he gives is merely a report, for they do not appear to have observed the sun, and his chart places it in 41° 40′. The high mountains, rising to an elevation of 3,400 feet behind the cape, might well be covered with snow if the winter was severe, as we may assume it was from the narrative.

They could not have been in 41° 30′, because after being driven northward by the violent southeaster for six days (to January 20) they were then only in 42°. Vizcaino's chart lays down a prominent headland in latitude 40½° (obtained by bringing up the scale of degrees from Point Pinos to Point Reyes) and a marked headland in 41°. Between these two capes he has a deep receding of the shore-line to the east and northeast, with a large river emptying into the northeast part of this great bight.

I am satisfied that this apparent eastern recession of the shore-line was the low country around Humboldt Bay and Eel and Mad Rivers. The large river which he has drawn was a supposition of its existence on account of the low lying valley in that direction giving passage way to the discolored waters of Mad River and Pigeon River.

Cabo Mendocino, Vizcaino's chart, 41° 40′.

Point St. George, in latitude 41° 46′.

South of Cape Mendocino Vizcaino notes the coast line as rugged, but no name appears until "Cabo Mendocino" stands abreast a cape of white cliffs in latitude 41° 40′, with mountains to the southward covered with snow. The shore-line from Trinidad to this cape is laid down straight, but for twenty miles it is continued to the northeast. He could not have been near the coast, on account of the heavy weather, or he would not have missed Redding Rock north of Trinidad, nor the notable cliffs of Gold Bluff in 41° 25′. And especially does he omit any sign of the rocky islets of the Dragon Rocks forming St. George's Reef in 41° 50′. As there is a marked recession of the high land behind Point St. George on account of large lakes and several streams making in from the distant mountains, he may have

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Tuesday, the twenty-seventh of the said month, the wind veered to the south-southwest, which held on all day; they ran to the west-northwest with the foresails lowered, for it blew violently; at the approach of night the wind shifted to the west; they ran all night to the south with but little sail; there was a high sea which broke over them.

"The ship progressed very slowly, but little by little, on Sunday the twelfth day of January [1603] the flag-ship came in sight of some very high mountains of a reddish color, and fourteen leagues farther to the north-west a chopped off cape came upon the sea, and near to it some snowy mountains; and the pilots judged that this should be the Cape Mendocino, which is [reported to be] in forty and one degrees of latitude.

"The day following, which reckons itself the thirteenth of January, a southeast wind came up with the greatest fury, and with it a fine sleet that appeared like snow. This wind raised such a tremendous sea, that every moment it appeared as if the ship must founder and all be lost; and to avoid its fury, and not to reach a higher latitude, because they feared the excessive cold and the increased violence of the storms in the higher latitudes, and it being the depth of winter, it was deemed the best to lay to until the wind was favorable and then make sail for Acapulco. * * *

"With this decision came a little strength to mitigate the sufferings of the people, for they now thought they would be able to hold out some days longer than if they went farther north.

"And on the fourteenth of the said month the weather cleared a little that day and the sun shone out, so that the pilots were able to observe, and they found themselves near to this Cabo Mendocino, and the currents had carried them even this far in two days. Almost immediately the sky was obscured that day with a thick fog, and dark, and a cold drizzle which they had not expected; and as the wind was still at southeast the ship lay to the sea with the wind abeam

supposed the shore receded more to the northeast than it really does.

El Cabo Blanco de San Sebastian.

Vizcaino does not state positively that this cape is in his observed latitude of 42°, which, by the way, is the only latitude he mentions in his narrative. His chart lays down a cape of white cliffs in 41° 40′, where he places Cape Mendocino. There are the white cliffs of the Gold Bluffs in 41° 25′, and the notable white sand dunes just north of Mack's Arch. These sand dunes are three miles in length and rise to 170 feet elevation and are a marked feature in the shore line. They lie in latitude 42° 14′ and the verdure-clad mountains behind them rise to 1,500 feet and are pine covered on the upper slopes and crest line.

In latitude 42° 05′ the Coast Survey has named a bold headland, seen from Pelican Bay, Cape Ferrelo, and in latitude 42° 18′ a second notable head has been named Cape Sebastian, but without other intention than commemorating these names.

"A Bad bay," Drake 42°.

Chetko Bay, latitude 42° 01′.

This is an open roadstead exposed to the full force of the southerly swell. It is at the southern termination of fifty miles of high rugged coast coming from Port Orford to the Chetko River. In striking the coast Drake could find no anchorage between Point Orford and this place, and none other near this except Crescent City Harbor, seventeen miles southward, and which he would hardly approach when the dangerous Dragon Rocks or St. George's Reef guarded the shore. Chetko anchorage is but slightly protected even from the northwest swell by the long rounding head of Cape Ferrelo, five or six miles to the west-northwest. The shore line to the westward is bound by rocks, and there are several sunken rocks with breaks upon them in the anchorage. We know from experience that it is not a comfortable anchorage; and it may very well be accepted as the anchoring place of Drake in latitude 42°.

Trinidad Head, latitude 41° 03′.

Redding Rock, latitude 41° 22′.

The tender was then off Trinidad Head in latitude 41° 03′, and supposing that they had observed the latitude correctly, he could have found no protection anywhere in the vicinity of Cape Mendocino in 40° 27′, or of Trinidad Head.

In their demoralized condition they were anxious to get shelter, and the first object they could find would be the Redding Rock in latitude 41° 22′, only five miles off a nearly straight coast-line. It is only eighty-three feet high and of limited extent, but sufficient to give a lee for such a small vessel; moreover it is evident that the storm was not very severe. This protection was his only refuge, and his reference to Cape Mendocino was merely to the nearest known landfall.

even to the nineteenth of January, on the evening of San Fabian and Sebastian, Martyrs. This day the wind came from the northwest and cleared the weather, and observing the altitude the pilots found themselves in forty and two degrees of latitude; and the coast has a Cabo Blanco, of white land, joined to some high snow covered mountains, and it is called *El Cabo Blanco de San Sebastian.*

"The 5 day of June, wee were forced by contrary windes to runne in with the shoare, which we then first descried, and to cast anchor in a bad bay, the best roade we could for the present meete with, where wee were not without some danger by reason of the many extreme gusts and flawes that beate vpon vs, which if they ceased and were still at any time, immediately upon their intermission their followed most nile thicke, and stinking fogges, against which the sea preuailed nothing, till the gusts of wind againe remoued them, which brought with them such extremity and violence when they came, that there was no dealing or resisting against them."

"In this place was no abiding for vs; and to go further north, the extremity of the cold (which had now vtterly discouraged our men) would not permit vs; and the winds directly beat against vs, hauing once gotten vs vnder sayle againe, commanded vs to the southward whether we would or no."

"World Encompassed," p. 115.

"With this wind the sick sailors are reanimated to assist those who are well, and with great labor they raise the sails, and set them to the wind, with the desire to come in sight of the land in search of the tender, and for reconnoitering the line of the coast.

"The Fragata, as I have said before, found herself without the flag-ship; believing she was going before, went in her following, and on the lookout for her; and being in latitude forty and one degrees, the southeast wind, which I mentioned, struck the flag-ship, and not being able to withstand the sea on her beam, she ran with the wind, so as to reach the shelter of the mainland; and very near to Cape Mendocino, under protection of a large rocky islet, she remained at anchor until the wind had passed; and after the wind had lulled, they continued their navigation, being close to the land;

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Cabo Blanco, Vizcaino (Flores), 43°.

Cape Orford, or Cape Blanco, in latitude 42° 51′.

North of this latitude the coast does not run to the northwest; on the contrary it trends nearly north (magnetic). Yet we may suppose that in running along the coast and making the cape with the northwest wind with its dangerous reef before him he fell back upon his instructions to return.

This cape has a water-worn face that shows whitish in the afternoon sun, but there is no river near it which he would dare to enter. In May, 1886, the cliffs around Cape Orford were mostly covered with verdure, and only small spaces showed whitish.

Taking his narrative as accurately descriptive, we may assume that his Cabo Blanco was the white sand dune line (just south of Cape Sebastian) in latitude 42° 14′, and already described. Hence the coast runs to the west of north to Cape Orford. After passing these bright dunes and keeping the coast-line moderately close aboard he would open the well marked valley of the Rogue River in latitude 42° 25′. This stream has a tolerably wide mouth and has been entered by vessels; but the current is very strong and there is a short breaking bar off the entrance; while outside of it there is a very dangerous reef which he would certainly avoid.

The Chetko River and Smith's River are in the deep bight of Pelican Bay under 42°, and he would hardly have run in there from around the Dragon Rocks. The Chetko mouth is closed by a gravel barrier in dry seasons.

On the 28th of February, 1543, they were out of sight of land, and probably in latitude 41½°, allowing a correction of one and a half degrees to his reported latitude.

"Y no tener puente." In Spanish, puente does not mean exactly "deck" when applied to a ship; it means the place where the batteries of a ship are situated.

They were probably in latitude 42° 30′ abreast of Rogue River and working their way back to El Cabo de Pinos; but they must have been seventy miles broad off the coast, which was therefore not visible. The logs were brought down the flooded rivers of this part of the coast; and they always have been a feature off the coast north of Mendocino.

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The Wednesday following, the twenty-eighth day of the said month, at daybreak, the wind shifted directly to the southwest, and it did not blow hard. This day they observed the latitude in forty-three degrees. Towards night the wind freshened and shifted to the south-southwest. They ran this night to the west-northwest with much difficulty, and Thursday at daybreak the wind shifted to the southwest with great fury, and the seas came from many parts, which harassed them much, and broke over the ships, which, not having the decks [as in a man-of-war], if God should not succor them, they could not escape, and not being able to lay to, of necessity they scudded northeast towards the land; and now, holding themselves for lost, they commended themselves to our Lady of Guadalupe, and made their promises [or offerings], and ran thus until three o'clock in the afternoon with much fear and labor, for they saw they were going to be lost, and already they perceived many signs of the land which was near, as small birds, and logs very fresh, which had floated from some rivers, although from the dark and cloudy weather the land did not appear. At this hour the Mother of God succored them with the grace of her Son, and there came a very violent rainstorm from the north, which made them scud all that night and the following day until sunset to the south, with the foresails

and on the nineteenth of January, the pilot Antonio Flores, who was in the tender, found himself in latitude forty and three degrees, where the land makes a cape, or point, which was named Cabo Blanco, and from which the coast begins to run to the northwest, and very close to it, he found a River of large volume, and deep, that upon its banks it had very large Ashes, Willows, Elders, and other trees of Castile; and wishing to enter it, the currents would not permit him."

[And thereupon Ensign Alferez Martin Aguilar, commander of the tender, and the pilot Antonio Flores, finding they were in a latitude beyond that mentioned in the Instructions of the Viceroy, that there was no appearance of the flag-ship, and that the crew were very sickly, agreed to return to Acapulco.]

from the twenty-seventh of February, until Thursday, the first of March, they ran the greatest danger, and still more on the night of the same day, and when it became daylight, they gave thanks to Our Lady, and to Her Blessed Son, for having saved them from so dark and terrible a night, because the storm is not felt so much in the daytime: and when the weather cleared up, on the first of March, they observed the sun, in forty and four degrees, with so much cold that they were freezing,

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On Saturday, March 3, 1543, they were approaching the coast south of Point Arena, but Ferrelo goes back in his narrative when he was north of Cape Mendocino. The large fresh water streams breaking through the coast line north of that Cape, and up to 42° are: Eel River in latitude 40° 38′, Humboldt Bay in latitude 40° 46′, Mad River in 40° 53′, Pigeon River in 41°, the Klamath River in 41° 34′, Crescent City in 41° 44′, Smith's River in 41° 54′, the Winchuk in 41° 58′, the Chetko River in 42° 02′, Pistol River in 42° 15′, and the Rogue River in 42° 24′. All of these bring down winter freshets of discolored water abounding in the uprooted trees from their banks.

El Cabo de Pinos, in latitude 38° 30′.

The mountain mass overhanging Fort Ross, and already described (pp. 222, 224, 228). I should judge the vessel to have been twenty five miles off the land and even somewhat to the southward of the cape. From the highest point attained, in latitude 42½°, to this position abreast Cabo de Pinos the vessel ran two hundred and seventy-five miles between the morning of March 1 and the evening of March 3, giving about five miles per hour. If they continued on their east-southeast course they should have seen Point Reyes and the Farallones off the Golden Gate.

La Isla de Juan Rodriguez, Ferrelo.

San Miguel Island and Cuyler's Harbor. (See pp. 206, 226.)

It broke on the reef which is in the middle of the harbor, and he was unacquainted with the dangers of Wilson's Reef off the approaches and with the best place to anchor under the western shore of the harbor. (See description under Isla de San Sebastian).

Puerto de la Isla de San Salvador, Ferrelo.

Smugglers' Cove.

Santa Cruz Island. (See p. 204.)

Ferrelo's port is the Smugglers' Cove on the short southeast side of Santa Cruz Island.

Isla de San Sebastian, Ferrelo's consort.

Santa Rosa Island. (See p. 206.)

This is the first time the Cabrillo narrative has mentioned the Island of San Sebastian. It specifies the south-southeast side of the island where he sought shelter. As the Fragata was off Cuyler's Harbor in the evening (about twelve hours after the Capitana had passed it) with a heavy blow from the northwest, he very naturally was afraid to approach the old anchorage because he evidently passed through the breakers and dangers of Wilson's Reef, over one mile in extent, that lie three miles off the

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furled; and because there was a high sea from the south, it broke over them each time at the bow, and swept over them as if over a rock, and the wind shifted to the northwest and the north-northwest with great fury, so that it made them run until Saturday, the third of March to the southeast, and to the east-southeast, with such a high sea that it made them cry out without reserve that if God and His blessed Mother did not miraculously save them they could not escape. Saturday at noon the wind moderated and remained at the northwest, for which they gave many thanks to our Lord. They suffered also in provisions, as they had only biscuit, and that damaged.

It appeared to them that there was a very large river, of which they had much indication, between forty and one degrees and forty and three, for they saw many signs of it.

This day, in the evening, they recognized the Cabo de Pinos, and on account of the high sea which prevailed they could do no less than run along the coast on the return course in search of a shelter. They experienced much cold.

Monday, on the fifth day of the said month of March, 1543, at dawn, they found themselves off the island of Juan Rodriguez, and they did not dare to enter the port on account of the great storm which prevailed, which broke the sea at the entrance of the harbor in fifteen fathoms; the wind was north-northwest; the entrance is narrow; they ran under the protection of the Isla de San Salvador on the southeast side;

and Saturday, on the third, they again turned round to examine el Cabo de Pinos, but owing to the strong wind they were forced to go

to la Isla de la Posesion, where they arrived on the fifth, and on account of the heavy breakers at the mouth of the harbor

they sought protection under the Isla de San Sebastian, under the side presented to the south-southeast,

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northwest point of the island of San Miguel; and probably continued through the San Miguel Passage seeking a lee under the shores of Santa Rosa Island; and found protection and anchorage between South Point and East Point under the shore facing to the south-southeast. The summit of Santa Rosa Island is in latitude 33° 57′, and rises to 1,500 feet elevation.

He must have remained here fourteen days while the other vessel was three days in Smugglers' Cove under Santa Cruz, and then searched for her consort at the Puerto de las Canoas, again at Smugglers' Cove, at San Diego, Port Quentin, and finally at the Island of Cerros.

There are four open anchorages on the south side of Santa Cruz Island and Smugglers' Cove at the short southeast side. To reach this anchorage he must have sailed along the north shore of San Miguel Island, Santa Rosa Island, and Santa Cruz Island, and rounded the easternmost point of the latter to find shelter, from the northwest wind, at Smugglers' Cove.

He previously says he observed the sun in forty-four degrees, *i. e.*, in 42½° latitude, after applying the probable correction.

San Buenaventura (El Pueblo de las Canoas) is only nineteen miles north-northeast from Smugglers' Cove. (See p. 204.)

Puerto de San Miguel.
San Diego Bay. (See pp. 192, 194.)

La Bahia de San Mateo.
Todos Santos Bay. (See p. 190.)

El Puerto de la Posesion.
Port San Quentin, Lower California. (See p. 184.)

La Isla de Cedros.
Cerros Island. (See p. 174.)

This ship, the Fragata, did not enter the port on Juan Rodriguez Island (Cuyler Harbor on San Miguel), but sought shelter under the south-southeast side of the Island of San Sebastian (Santa Rosa Island). (See p. 236 for

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and the night before coming with a violent tempest, with only two small foresails, the other ship disappeared, so that they suspected that the sea had swallowed it up, and they could not discover it any more, even after daybreak;

they believe they must have been in forty-four degrees when the last storm overtook them and compelled them to run to leeward.

Thursday, the eighth of the said month, they departed from the island of San Salvador, to stand in for the mainland in search of the other ship, and they proceeded to Pueblo de las Canoas and did not obtain news of the other ship; and here they took four Indians.

The Friday following, on the ninth of the said month, they departed from Pueblo de las Canoas and proceeded to the island of San Salvador and found no signs of their consort.

Sunday, the eleventh of the said month, they came near the Puerto de San Miguel, neither did they find here their consort nor any news of her; here they waited six days; here they took two boys to carry to New Spain for interpreters, and left certain signals in case the other ship should approach.

Saturday, the seventeenth of the said month, they departed from the said Puerto de San Miguel; the following Sunday they arrived off the Bahia de San Mateo and found no signs of the other ship.

Sunday, the eighteenth of the said month, in the evening, they departed from this bay of San Mateo, and the Wednesday following, on the twenty-first of the said month, they arrived at Puerto de la Posesion, and still obtained no news of their consort; they waited two days without entering the harbor, for they did not dare to enter it on account of the heavy northwest wind which blew, and, as they parted their cable, of necessity they got under way.

Friday, on the twenty-third of the said month, they departed from Puerto de la Posesion, and the following Saturday at midnight they arrived off Isla de Cedros, and being there the following Monday, the twenty-sixth of the said month, arrived the other ship off Isla de Cedros, at which they rejoiced much and gave many thanks to God;

this ship passed by La Isla de Juan Rodriguez, at night, passing through some breakers so that they thought they must be lost, and the mariners promised to go in procession naked to her church and our Lady delivered them.

and that night [of the great storm] the flag-ship disappeared; and in five days they ran two hundred leagues, with reefed foresail, and there was nothing more to eat, but rotten biscuit, and they dealt out one pound per ration.

Thursday, on the eighth of the said month, they departed from El Puerto de San Sebastian, in search of the other vessel, and the whole crew made their demands that they should return to New Spain, as we had nothing that we could eat; and because this was in reason, they ordered the return, searching for their consort.

and they found her by chance at the Isla de Cedros, on the twenty-sixth of said month:

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mention of the dangers off the northwest shore of San Miguel Island.)

The ships arrive at El Puerto de Navidad, in New Spain, April 14, 1543.

"de letra del tiempo," *i. e.*, in an old manuscript of that period.

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On Monday, the second day of the month of April, they departed from the Isla de Cedros on their return to New Spain, because they did not have a supply of provisions to renew their attempt to discover the coast. They arrived in El Puerto de Navidad Saturday, the fourteenth day the said month of April [1543].

Came as Captain of the ships, Bartolomè Ferrelo, Chief Pilot of the said ships, in default of Juan Rodriguez Cabrillo, who died in Isla de la Posesion. The men came in the said ships.

(1) So in the original, without doubt by equivocation.

(2) He speaks of the port where they anchored in twenty-eight degrees.

(3) An equal blank in the original.

Found without the name of the author, in the general archives of the Indias of Seville, in the writing of the time, among the papers brought from Simancas. File nine of Descriptions and Populations.

Examined and approved.

MARTIN FERNANDEZ DE NAVARRETE.

There is another copy of this narrative in the collection of Muñoz, Vol. XXXVI, in which he inserts after his certificate of approval: "At the head and on the cover of this narrative occurs three times, De Juan Paez."

The differences which are noticed between the present narrative and that one are: (4) 3° and ¾; (5) Nor nordeste sudueste; (6) The last two names are united thus, Quanmugua; (7) Anacoac; (8) Caacac; (9) Xuca; (10) Caco.

and Saturday, on the fourteenth of April, they arrived at the Puerto de Navidad, of the return voyage, sadness, because to have died in it their Captain Juan Rodriguez Cabrillo, of infirmity, a good man, and very well versed in navigation; and for that of this coast these sailors said that large ships of two hundred tons are necessary, very fast, and well provided with sails, rigging, and cables, and that the sails be from Castile, because those from this country, split every moment, and that they should take a large supply of provisions: and that no Indians should go, because in the voyage they are of no use, and eat the provisions; and finally these vessels went as far as the forty-four degrees.

The landfalls of Cabrillo (C.) and Ferrelo (F.), with their names by Ulloa (U.),

No.	Dates, 1542, 1543.	Name of place by Cabrillo and Ferrelo.	Latitude by Cabrillo and Ferrelo.	Names by Ulloa, Drake, or Vizcaino.
1	June 27, 1542.. Apr. 14, 1543..	El Puerto de Navidad..........	C., F..............	El Puerto de la Navidad, V.........
2	June 29, 1542....	El Cabo de Corrientes	20¼°, C.............	El Cabo de Corrientes, V..........
3	July 2, 1542......	La Punta de California	24° "and more," C...	....
4	....	El Puerto del Marques del Valle. El Puerto de la Cruz..........	....do ....do	La Bahia de Santa Cruz, U.........
5	July 6, 1542......	El Puerto de San Lucas........	C., F	La Bahia de San Bernabè, V.......
6	July 8, 1542	El Puerto de la Trinidad.......	25°, F..............	La Bahia de San Abad, U.; La Bahia de Santa Marina, V.
7	July 8, 1542	La Punta de la Trinidad.......	25°, C., F	....
8	July 8, 1542	Una Isla......................	F	....
9	July 13, 1542	El Puerto de San Pedro........	25½°, F.............	El Puerto de la Magdalena, V......
10	....	La Bahia de San Martin........	F	La Bahia de Santa Marta, V ......
11	July —, 1542	Una Gran Ensenada	26°, F..............	....
12	July 19, 1542.....	El Puerto de la Magdalena.....	27°, C., F	....
13	July —, 1542.....	La Punta de Santa Catalina....	....	....
14	July 25, 1542.....	El Puerto de Santiago	27½°, F.............	La Bahia de las Ballenas, V ....
15	July —, 1542.....	Habre Ojo....................	27½°, F.............	Abreojos, V.'s chart ....
16	July —, 1542.....	Punta y Puerto de Santa Ana ..	28°, F..............	....
17	July —, 1542.....	Una Isleta obra de una legua de Tierra.	28°, F..............	La Isla de San Roque, U., V ....
18	July 27, 1542.....	El Puerto Fondo...............	F	....
19	July 31, 1542.....	[Anchorage]	F	....
20	Aug. 1, 1542.....	El Puerto de San Pedro Vincula.	28½°, "and more," F.	El Puerto de San Bartolomè, V .....
21	Aug. 2, 1542......	La Isla de San Esteban	F	La Isla de Natividad de Nuestra Señora, V.
22	Aug. 2, 1542......	Una Ensenada Grande	F	....
23	Aug. 5, 1542... Mar. 26, 1543..	La Isla de Zedros.............	29°, F..............	La Isla de los Cedros, U.; La Isla de Cerros, V.
24	Aug. 11, 1542.....	El Puerto de Santa Clara	30°, "scant," F.....	La Bahia de San Hipolito, V ......
25	Aug. 15, 1542.....	La Punta del Mal Abrijo	30½°, F	....
26	Aug. 19, 1542.....	La Isla de San Bernardo	30½°, F	La Isla de San Gerónymo, V.......
27	Aug. 20, 1542.....	El Cabo del Engaño .... La Punta del Engaño.........	31°, C .... 31°, F	El Cabo del Engaño, 30°, U ....do ....
28	Aug. 21, 1542.. Mar. 21, 1543..	El Puerto de la Posesion	31½°, F	La Bahia de las Virgines, V........

Drake (D.), and Vizcaino (V.), and the present names and latitudes.

Present name of the place.	Latitude.	Correction to C., F., or D.	Remarks.	No.
	° ′			
Port Navidad	19 13			1
Cape Corrientes	20 25	—05′	It is more than probable that Cabrillo assumed the latitude as given by previous navigators.	2
Cape Pulmo	23 23	—37′ "and more," C.		3
Anchorage under Cape Pulmo	23 23	—37′ "and more," C.		4
San Lucas Bay	22 52		Cabrillo did not observe the latitude. "They say it is in latitude 23°," F.	5
Santa Marina Bay	24 20	—40′, F.		6
Capo Tosco	24 17	—43′, C., F	The SE. point of Santa Margarita Island	7
Santa Margarita Island	24 17		The island is 22 miles long	8
Magdalena Bay	24 32	—58′, F		9
Santa Maria Bay	24 44			10
			There is no gulf; but the lowland north of Cape Lazaro slightly recedes, and would mislead a navigator in a small vessel in the offing.	11
Pequeña Bay and Point	26 14	—46′ C., F	Ferrelo says: "It is 40 leagues from the Bay of San Martin to this coast."	12
San Domingo Point and Anchorage.	26 19			13
Ballenas Bay	26 45	—45′ F		14
Abreojos Rocks	26 46	—44′ F	A dangerous reef of visible and sunken rocks.	15
Asuncion Point and Anchorage	27 07	—53′ F		16
Island of San Roque	27 09	—51′ F	Ulloa saw the two islands, Asuncion and San Roque.	17
Table-Head Cove, or San Pablo Bay.	27 11			18
Bay of San Cristoval				19
Port San Bartolomè	27 39	—51′ "and more," F.		20
Natividad Island	27 53		The Afégua, or Bird Island of Father Taraval, 1734.	21
Sebastian Vizcaino Bay	27 45 to 28 35		This is the Gulf of San Xavier, of Father Taraval. It is 50 by 60 miles in extent.	22
Cerros Island	28 02	—58′ F	They anchored under the south shore. This is the Amalgua, or Fog Island, of Father Taraval, 1734.	23
La Playa Maria Bay	28 55	—65′ "scant," F	They anchored here	24
Point Canoas	29 25	—65′ F	do	25
San Gerónimo Island	29 48	—42′ F	do	26
Point Baja	29 56	—64′ C		27
do	29 56	—64′ F		
Port San Quentin	30 24	—66′ F		28

The landfalls of Cabrillo (C.) and Ferrelo (F.), with their names by Ulloa (U.),

No.	Dates, 1542, 1543.	Name of place by Cabrillo and Ferrelo.	Latitude by Cabrillo and Ferrelo.	Names by Ulloa, Drake, or Vizcaino.
29	Aug, 30, 1542	La Isla de San Augustin	F	La Isla de Cenizas, V. La Isla de San Hilario, V.
30	Sept. 4, 1542	[Anchorage, 7 leagues from San Augustin.]	F	
31	Sept. 8, 1542	El Cabo de San Martin	32½°, F	
32	Sept. 11, 1542	El Cabo de la Cruz	33°, C.	
	Sept. 11, 1542	El Cabo de Cruz	33°, F.	
33	Sept. 11, 1542	Una Isleta	F	
34	Sept. 17, 1542. Mar. 18, 1543.	El Puerto de San Mateo	33½°, F	La Ensenada de Todos Santos, V.
35	Sept. 26, 27, 1542.	Las Islas Desiertas	34°, F	Las Islas de los Coronados, V.; Las Islas de San Martin, V.'s chart.
36	Sept. 28, 1542. Mar. 11, 1543.	El Puerto de San Miguel	34½°, F	El Puerto de San Diego, V.; El Puerto Bueno de San Diego, V.'s chart.
37	Oct. 7, 1542	La Isla de San Salvador	F	La Isla de Santa Cathalina, V.
38	Oct. 7, 1542	La Isla de la Vittoria	F	
39	Oct. 8, 1542	La Bahia de las Fumos	35°, F	
		La Bahia de los Fuegos	F	
40	Oct. 9, 1542	[Anchorage]	F	
41	Oct. 10, 1542	Los Pueblos de las Canoas	35½°, C	
	Mar. 8, 1543	El Pueblo de las Canoas	35½°, F	
42	Oct. 13, 1542	[Anchorage]	F	
43	Oct. 14, 1542	[Anchorage]	F	
44	Oct. 15, 1542	[Anchorage]	F	
45	Oct. 16, 1542	[Anchorage]	F	
46	Oct. 17, 1542	[Anchorage]	F	
47	Nov. 2–6, 1542	El Pueblo de las Sardinas	C	
		Los Pueblos de las Sardinas	F	
	Feb. 12–14, 1543	El Puerto de las Sardinas	35½°, F	
48	Nov. 1, 1542	El Puerto de Todos Santos	F	
49		El Pueblo de Xexo	F	
50	Oct. 18, 1542	El Cabo de la Galera	36½°, C	
		El Cabo de Galera	36° "and more," F	
51	Oct. 15, 1542	La Isla de San Lucas	F	
52	Oct. 18, 1542	Las Islas de San Lucas	C., F	
53	Oct. 25, 1542	La Isla de la Posesion	C., F	La Isla de Baxos, V
	Dec. —, 1542	La Isla de Posesion	F	
54	Dec. —, 1542	Una de las Islas de San Lucas	C	

Drake (D.), and Vizcaino (V.), and the present names and latitudes—Continued.

Present name of the place.	Latitude.	Correction to C., F., or D.	Remarks.	No.
	° ′			
San Martin Island	30 29			29
San Ramon Bay	30 49			30
Point Santo Tomas, or Cape San Tomas.	31 33	—57′ F	The anchorage under the cape	31
Grajero Point, or Banda Point	31 45	—75′ C	Distance from Cape San Martin, 4 leagues	32
......do	31 45	—75′ F		
The Todos Santos Islands	31 48			33
The Ensenada in Todos Santos Bay.	31 51	—89′ F	Anchorage in the northeast part of Todos Santos Bay.	34
Los Coronados Islands	32 25	—95′ F		35
San Diego Bay	32 40	—100′ F	He has one of the largest errors in the best-known port.	36
Santa Catalina Island	33 27		At the great depression across the island	37
San Clemente Island	32 49		At the southeast head	38
Santa Monica Bay	34 00	—60′ F		39
......do				
The Anchorage off Laguna Mugu	34 05			40
San Buenaventura	34 17	—63′ C		41
......do	34 17	—63′ F		
Anchorage off "the Rincon"	34 22			42
Anchorage off "the Carpinteria"	34 24		A few miles east of Santa Barbara	43
Anchorage 4 or 5 miles west of Goleta Point.	34 25			44
Anchorage off the Cañada del Refugio.	34 27			45
Anchorage off Gaviota Pass	34 27			46
The Indian Villages at Gaviota Pass.	34 28		Ferrelo says the Indian name was Cicacut	47
Anchorage off Gaviota Pass	34 27	—73′ F		
Anchorage off El Coxo	34 28		There are two Coxos. The Coxo Viejo is one mile east of the usual anchorage El Coxo.	48
Indian Village at El Coxo	34 29			49
Point Concepcion, or Point Conception.	34 27 34 27	—123′ C —93′ "and more," F.	La Punta de la Concepcion of recent Spanish navigators.	50
The three islands, Santa Cruz, Santa Rosa, and San Miguel.			They overlap each other, and were seen as one great island.	51
San Miguel, and then Santa Cruz and Santa Rosa as one.			One large—Santa Cruz and Santa Rosa—and one small, which was San Miguel.	52
San Miguel Island	34 03		Ferrelo says the Indian name was Ciquimuymu.	53
......do				
......do				54

The landfalls of Cabrillo (C.) and Ferrelo (F.), with their names by Ulloa (U.).

No.	Dates, 1542, 1543	Name of place by Cabrillo and Ferrelo.	Latitude by Cabrillo and Ferrelo.	Names by Ulloa, Drake, or Vizcaino.
55	Jan. 3, 1543... Mar. 5, 1543...	La Isla de Juan Rodriguez.....	F............	....
56	Oct. 25, 1542	El Puerto de la Posesion	C., F.................	....
57	Mar. 5, 1543.......	[Dangers]....................	F.'s consort..........	....
58	Jan. 29, 1543	La Isla de San Lucas	F........	La Isla de Cleto, V...............
59	Mar. 5, 1543......	La Isla de San Sebastian.......	F.'s consort..........	....
60	Jan. 19, 1543 .. Feb. 14, 1543..	La Isla de San Salvador	F.......	La Isla de San Ambrosio, V ....
61	Nov. 11, 1542.....	El Rio de Nuestra Señora	C......	....
62	Nov. 11, 1542.....	Las Sierras de San Martin	37½°, C., F...........	La Sierra de Santa Lucia, V........
63	Nov. 11, 1542....	El Cabo de San Martin	38°, F	La Punta de Pinos, V.............
64	Nov. 11, 18, 1582..	El Cabo de San Martin	37½°, F	....
65	Nov. 18, 1542.....	El Cabo de Nieve..............	28⅜°, C., F...........	....
66	Nov. 18, 1542.....	(De las Sierras Nevadas)	F	....
67	Nov. 16, 1542....	La Baìa de Pinos	C.............	Portus Novæ Albionis, 38°, D ....
	Nov. 16, 1542....	La Bahìa de los Pinos..........	39° "and more," F...	El Puerto de San Francisco, V .....
68	Nov. 14, 1542 ...	El Cabo de Pinos	40° "and more," C...	....
	Feb. 25, 1543.. Mar. 3, 1543...	El Cabo de Pinos	40°, F.......	....
69	Feb. 25, 1543.....	A point, &c	F	....
70	Feb. 26, 1543.....	El Cabo de Fortunas...........	41°, C	....

Drake (*D.*), *and Vizcaino* (*V.*), *and the present names and latitudes*—Continued.

Present name of the place.	Latitude.	Correction to C., F., or D.	Remarks.	No.
	° ′			
San Miguel Island			So named by Ferrelo to commemorate Cabrillo's death on the island.	55
Cuyler's Harbor	34 03		Cabrillo and Ferrelo wintered here in 1542–1543; it is on the north shore of San Miguel Island.	56
Wilson Rock, &c	34 06¼		The rocks and reefs off the northwest shores of San Miguel Island.	57
Santa Rosa Island	33 57		Ferrelo says the Indian name was Nicalque.	58
......do				59
Santa Cruz Island	34 02		Ferrelo says the Indian name of the island was Limu or Limun.	60
La Purisima, or Santa Ynez River.	34 42		Cabrillo and Ferrelo did not see it. They learned of its existence north of Point Concepcion from Indian information when in the Santa Barbara Channel.	61
Sierra Santa Lucia	36 03	—87′ C., F	This mountain range is 50 miles long and overhangs the coast line. The culminating point is Mount Santa Lucia, 6,000 feet elevation and 12 miles inside the shore.	62
Point Pinos	36 32	—88′ F		63
The Twin Peaks	36 03	—87′ F	The height is 5,100 feet, and the distance 3¼ miles inland.	64
Black Mountain	37 09	—91′ F	The mountain mass 13 miles behind Point Año Nuevo.	65
The Santa Cruz Mountains			Embracing Black Mountain	66
Anchorage in Drake's Bay	38 00	—00′ D	The northern part of the Gulf of the Farallones.	67
Drake's Bay, or the Gulf of the Farallones.	38 00	—60′ F	"A great gulf," Cabrillo (Una Ensenada Grande.)	
The Northwest Cape	38 31	—89′ "and more." C.	The mountain mass just east of Fort Ross anchorage, and reaching 2,200 feet elevation.	68
......do	38 31	—89′ F		
Point Arena	38 57		La Punta de Arena of later Spanish navigators.	69
King Peak, behind Punta Delgada.	40 00	—60′ C	The mountain mass northward of Shelter Cove, with King Peak only 10 miles inland and 4,235 feet elevation, as the culminating point.	70

INDEX TO APPENDIX NO. 7—1886.

PREFATORY NOTE.

In consulting this index and the paper to which it relates, it will be of much advantage to refer to the map (Illustration No. 18) which Assistant Davidson has prepared to show the landfalls of Cabrillo and Ferrelo on the Pacific coast.

The several items of nomenclature and other references, embracing all appearing in the original paper, are herein indexed in groups, under the following headings, for convenience in collating the descriptions; but for a condensed statement of the names and positions of the places mentioned by Cabrillo and Ferrelo, and which have been identified by Assistant Davidson, see his table, pp. 242–247.

AUTHORITIES AND PUBLICATIONS CONSULTED OR REFERRED TO.
DISCOVERERS AND EXPLORERS.
HARBORS (PORTS) AND ANCHORAGES, BAYS, CHANNELS, COVES, GULFS, LAGOONS, STRAITS.
HEADLANDS: CAPES, POINTS, BLUFFS.
ISLANDS, REEFS, AND ROCKS.
MOUNTAINS AND MOUNTAIN RANGES (SIERRAS), TABLE-LANDS (MESAS).
RIVERS AND STREAMS.
SETTLEMENTS: INDIAN VILLAGES (PUEBLOS).
MISCELLANEOUS NOTICES.

AUTHORITIES AND PUBLICATIONS CONSULTED OR REFERRED TO.

[For the full titles of the principal publications named in the introduction, see pp. 156, 157, 158.]

DISCOVERERS AND EXPLORERS.

[Names to be found generally throughout this paper for the period in question.* For those casually alluded to, see pages as under.]

HARBORS (PORTS) AND ANCHORAGES, BAYS, CHANNELS, COVES, GULFS, LAGOONS, STRAITS.

HEADLANDS: CAPES, POINTS, BLUFFS.

Islands, Reefs, and Rocks.

MOUNTAINS AND MOUNTAIN RANGES (SIERRAS), TABLE-LANDS (MESAS).

RIVERS AND STREAMS.

SETTLEMENTS: INDIAN VILLAGES (PUEBLOS).

MISCELLANEOUS NOTICES.

APPENDIX No. 8.—1886.

A REPORT ON MONOMOY AND ITS SHOALS.

By HENRY MITCHELL, Assistant.

COAST AND GEODETIC SURVEY OFFICE, *June* 25, 1886.

The peninsula of Monomoy and the group of shoals about it present dangers that affect the commerce between the States to a greater degree perhaps than any other obstructions; for here, at the eastern entrance to Nantucket and Vineyard Sounds, pass about 30,000 vessels annually, and occasionally 300 in a single day—the maximum of the year. These 300 vessels average 200 tons measurement, giving a total of 60,000 tons, and represent, with cargo, $3,000,000.

These vessels not only run the gauntlet among these natural dangers, but they endanger each other by crowding into the fair-ways. The principal avenue—Butler's Hole—has only half the width that it had a century ago, and its course has of late years very materially changed.

Every foot of width where safety is assured has a value, and if the limits of the shoals could be accurately defined there would be a great reduction in the real danger and, most of all, in the fear of danger which delays the fleet in thick weather. In the measure that we can furnish the coaster with accurate charts and marks of this locality we reduce his danger and his fears, which tax the community.

The real source of trouble is the constant shifting of these shoals and their growth. We speak within the truth when we assert that these shoals have doubled their volume since the last century, and they have moved a mile in the average. The worst of it is that the movement is very far from uniform in rate or direction for different members of the group.

This neighborhood was designated by Champlain (1605) *Cap Batturier*, conveying the impression, by this name and the context in his narrative, of a projecting region of breaking flats. At the present rate of building, the dry land of Monomoy could scarcely have been half the present length at the time of Champlain, and, if half the bulk, it must have been submerged.

The present aspect of the case is very threatening to navigation. It looks as if the sea would soon break from Monomoy to Nantucket on the summit of the circus that is formed by Pollock Rip, Great Round Shoal, and Great Point Rip, with their connections. The present broken wall has material enough in it to close the ship navigation, if this material should be strewn along more uniformly by some great storm so as to connect more intimately the chain of shoals. Moreover, there is plenty of new material supplied from the caving down of the Chatham shore. This caving has been very active of late years, and forms the theme of Appendices to Annual Reports of the Coast Survey for 1871 and 1873. The beach in front of the town of Chatham began to break up in 1871, and Professor Peirce, then Superintendent, ordered special surveys, which were executed by Assistant H. L. Marindin, and formed the subject of reports by myself.

The earliest chart of this neighborhood based upon anything like a regular survey seems to be that of Capt. Paul Pinkham, made at the time that the present light-house was being built upon Great Point Nantucket in 1784. There are plenty of earlier charts, and there are sailing directions as far back as 1707; but the Paul Pinkham chart, on the whole, furnishes the first reliable testimony relative to the location of shoals at the entrance to the Vineyard Sound. I beg

leave to offer an analysis of this testimony in detail because of its importance, and because I fear that the chart of which I speak is likely otherwise to be confounded with a later one by the Blunts, assuming to be "surveyed by Capt. Paul Pinkham," which is singularly out in its longitudes and in its distances.

The following appears upon the chart, which I have used as my base of comparison:

A CHART OF NANTUCKET SHOALS SURVEYED BY CAPT. PAUL PINKHAM.

[Boston: Published and sold by William Norman, No. 75 Newbury street, February 16, 1791.]

To all whom it may concern:

As there never has yet been published an accurate chart of Nantucket Shoals,

These are to certify that when the Light-house was building on Nantucket Point, in 1784, this survey of the shoals was made from the lantern (an opportunity never before had for so valuable a purpose) by Capt. Paul Pinkham and others, by the help of the best compasses and instruments that could be procured, and it has been proved by experience to be the most accurate chart ever offered to the public of those dangerous shoals (which are a terror to all navigators), which has been run by with greatest safety and is fully approved, and that the publication of this chart, from its accuracy, cannot fail to be greatly beneficial to all navigators who may fall in with said shoals, is the judgment of us.

NANTUCKET, *Sept.* 1, 1790.

JNO. CARTWRIGHT.
JOS'H CHASE.
DAN'L COFFIN.
NATH'L BARNARD.
JAS. BACKER.
WM. COFFIN.
ALEX. COFFIN, JUN.
THOS. DELANO.

The many surveyors who have attempted the survey of the island of Nantucket, with the shoals around it, and whose charts have been published, have, from experience, proved very incorrect and erroneous, more particularly the shoals which, lying at so great a distance from the land, have hitherto been laid down from information only; from hence has arisen great errors and inaccuracies in the various charts published of those shoals.

On considering their dangerous situation and the dread they are to all navigators who frequent the coast, as well as the great utility of a correct chart, I have been induced to use my best endeavors to obtain a new and accurate survey of the shoals eastwardly of the island, being taken from the light-house on Nantucket Point in 1784, which eminence afforded a large and distant prospect of the shoals, and from which their true bearing was had with precision and certainty. I hereby certify that the chart hereunto annexed, having been carefully examined by warrantable pilots and navigators and run by for some years with safety, is fully approved and by them certified.

NANTUCKET, *September* 1, 1790.

PELEG COFFIN, JR.

The scale of this map is about 1:137580. It is the property of the Nantucket Athenæum.

It will be observed from the foregoing that the claim of accuracy particularly applies to the region seen from the Light-house which is plotted on this old chart in latitude 41° 22′, longitude 70° 00½′. It is the same Light-house that now stands, and is found by latest survey, in 41° 23′ 24″ of latitude, and 70° 02′ 45″ of longitude. The former determination, on the Paul Pinkham chart, was then 2¼ miles too far to the east-southeast. This error, however, need not concern us if we confine our inquiries to objects within sight of the Light-house; and first of all we must seek those that have not changed, in order to orient ourselves.

From Matthew Clark's chart of this neighborhood, indorsed by Osgood Carleton, for the Boston Marine Society (1798), the variation in the compass as used seems to have been 6° 45′;

No. 19

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and, as the Paul Pinkham chart is evidently adjusted to the magnetic meridian, we have corrected for variation (as finally ascertained to be about 6½° west) in the following bearings:

"Bishop and Clarks" Rocks on Paul Pinkham's chart lie 15¼ nautical miles N. 39¼° W. (true) from Great Point. Bishop and Clerks on the most recent chart lie 14¼ nautical miles N. 39¼ W. of Great Point light.

The distances are measured for the old chart, not by its scale, but by minutes of latitude. I would remark here that the Paul Pinkham chart is a pretty good projection, with ratio of 1 : 1.3 for longitude and latitude divisions; but the scale of miles seems to be minutes of longitude.

There is, upon the northeastern portion of Tuckernuck, a sort of lagoon, at the head of which is quite a hill, upon which there was at the time of Paul Pinkham, and still is, a group of houses. This hill as represented upon the Coast Survey charts, lies W. 30° S. from Great Point Light distant 10¾ nautical miles. Upon Paul Pinkham's chart the head of the lagoon bears W. 29½° S., distant 11 nautical miles. The lagoon is known as East Pond, and the hill that rises at its head is a very conspicuous landmark.

These three points, Bishop and Clarks, Tuckernuck, and Great Point Light, are all that we can feel sure of as remaining unchanged.

Great Round Shoal.—If we draw a circle through the three shoalest soundings upon the Coast Survey chart we find its center N. 55° E. from the Great Point Light-house, distant 7¾ miles. On the Paul Pinkham chart it is represented by a circular line of dots, the center of which is N. 60¾° E. of Great Point light, 7½ miles distant.

Little Round Shoal.—The shoalest water lies N. 39½° E. of Great Point Light, upon our most recent charts, distant 8 miles. Upon Paul Pinkham's chart it is indicated by a circle of dots, the center of which is N. 40¾° E. from the Light, distant 7 miles. This shoal is not easily distinguished from the Stone Horse.

"*Broken part of Pollock Rip*" lies N. 37½° E., 11½ miles from the Light, on the Coast-Survey chart, and N. 35½° E., 14¾ miles on Paul Pinkham's. This is rather beyond the range of vision from the Light-house, except for a wreck, and hard to distinguish, the shoals being numerous.

Stone Horse.—The middle of this shoal, as well as can be determined, lies about in the same direction upon old and new charts, N. 22¼° E. from Great Point Light. Its distance, according to Paul Pinkham's chart, was 8½ nautical miles. It is now 7¾, *i. e.*, the shoal has moved about three-quarters of a mile toward the Light.

Handkerchief Shoal.—This shoal has very much increased in size, and *worked* or extended southward. The least depth is the same (4 feet) now as upon Clark's map of 1798; but this figure lies about 1 mile farther from Great Point Light on Clark's chart than upon our own. The southern point of the shoal is given N. 2° W., 8¾ miles from Great Point Light, by Pinkham while by Clark it is 7½ miles due north, and upon the recent Coast Survey chart 6¼ miles N. 7¾° W.

The northern or northeastern portion of the shoal has not essentially changed, being the same for Pinkham, Clark, and the Coast Survey, but the growth southward has exceeded one mile in the past century.

Upon both of the old charts (Pinkham and Clark) the sailing course for the "North Channel" was laid down north of the Handkerchief, and ran across what is now dry land near the present Monomoy Light.

Clark's representation of Monomoy indicates a great extent subject to overflow, so that it is difficult to make comparisons between it and other plottings.

Butler's Hole.—This most frequented channel was about 1.9 miles wide upon Pinkham's chart, 1 mile on Clark's, and little more than a half mile at the time of the most recent surveys. As might have been expected, Butler's Hole has increased in depth as it has lost in width. We find nearly 20 fathoms on the site where the old charts gave 15 as maximum depth. The present maximum depth is 23½ fathoms.

Before entering upon the more modern history of this region, we must call attention to what we may designate as the *deep hole*, indicated by the sounding of 24 fathoms upon Paul Pinkham's chart. This sounding is plotted 7½ nautical miles N. 71¾° E. of Great Point light. McBlair, in 1849, found 21¾ fathoms at a distance of 6 miles N. 79¾ E., and Captain Brownson, at the margin of his survey of 1883, gives 20 fathoms and no bottom, 7 miles N. 77½° E. of Great Point Light. There seems

to be no doubt that a gully of considerable extent exists which our printed chart does not properly represent; and it is believed that this gully is a permanent feature, notwithstanding that our bearing differs from Paul Pinkham's very largely. It must be borne in mind that the bearings of *breaking shoals* could be accurately taken from Great Point light tower; but a *deep hole* makes no sign.

This gully lies so near the proper track of the South-Channel fleet that its careful representation upon the chart would be a valuable guide to navigation, while its absence from the chart, or entirely inadequate rendering, provides for disaster. Some vessel standing in from seaward in thick weather may happen to cast her lead in this deep place, and, believing herself outside of all the shoals, sail on to her destruction.

There is reason to believe that Great Round Shoal and this gully are to be found just where they always have been. The sailing line on Paul Pinkham's chart of 1784, if plotted upon our own chart, lies very near the southern slope of this gully, and between it and our most recent sailing line. But why this gully should not fill up, in this region of strong tidal currents laden with sand, is a mystery. It might be worth while to take some current observations and ascertain if *a resultant* occurs here not elsewhere developed.

Monomoy Point.—This is well defined on Desbarres' chart of 1777, and on Pinkham's of 1791; but on Matthew Clark's chart, 1798, it is represented as if awash. The distances across from Great Point to Monomoy are: on Desbarres' chart (1777), 14 nautical miles; on Paul Pinkham's chart (1784-'91), 11¼ nautical miles; on Matthew Clark's chart (1798), 10½ nautical miles; United States Coast Survey (1868), 9¼ nautical miles. Matthew Clark's chart only assumed to be a correction of Desbarres', while Paul Pinkham's was from a new survey.

There seems always to have been a shoal off the extreme point of Monomoy known as "Egg Island," when dry. This shoal has sometimes attached itself to the end of Monomoy, but oftener has been separated by a deep slough channel. If we ignore the slough channel that now separates the point of Monomoy from the Shovelful Shoal (the re-appearing Egg Island in an advanced position), we reduce the distance across from Great Point to less than nine nautical miles (1875). It should be noted here that Great Point Nantucket has lost, by fits and starts, considerable length. Paul Pinkham found the extreme point in 1784 over 3,000 feet beyond the present light-house, then in course of construction; Assistant Henry L. Whiting's topographical survey of 1846 gives this distance 1,900 feet, and Assistant F. D. Granger, on his hydrographic sheet of 1874, places the point (by a signal as near as possible to the high-water breaker) about 1,600 feet from the light-houses.

We have every reason, then, to believe that the dry land of Monomoy has extended southward two miles during the past century.*

The first survey of Monomoy made by a professional topographer was that of Mr. Charles O. Boutelle, then attached to the trigonometrical survey of Massachusetts, in 1840. At that time the point lay 2,681 feet S. 3,837 W. of the Light-house then standing. (See Captain Boutelle's report, addressed to Superintendent Coast and Geodetic Survey, 16th June, 1886, appended.)†

In 1853 Assistant S. A. Gilbert, of the Coast Survey, made a plane-table survey, and found the extreme point of Monomoy 2,821 feet S. 3,542 feet W. of the "Old Light-house" referred to by Mr. Boutelle. The first twelve to thirteen years of authentic history only advanced this point about 140 feet.

The next survey was by Assistant C. T. Iardella, of the Coast Survey, in 1856, when the extreme point was found to be 3,180 feet S. 3,906 feet W. of the "Old Light-house," showing an advance of 509 feet SW. in three years, or at rate of 170 feet per annum.

* There is a mysterious chart in the archives of the Coast and Geodetic Survey entitled, "A chart of George's Bank, including Cape Cod, Nantucket, and the shoals lying on their coasts, surveyed by Captain Paul Pinkham," and "published by Edmund M. Blunt, 1797." This chart, ostensibly six years later than the "Chart of Nantucket Shoals" (which we have found so valuable), is comparatively absurd. It is a whole degree out in longitude, and it gives, for the distance from Great Point to Monomoy sixteen minutes of latitude; and yet the bearing and distance of George's Shoal were more nearly correct than upon any previous chart. Its scale is about 1 : 400000.

† Captain Boutelle's testimony against the map made by John G. Hale in 1831 rules it out of court; but I may be allowed to state that upon that map the point is represented as about 1,650 feet south of the light, and the *Powder Hole Harbor* is absent. There is no doubt, in my own mind, that the testimony of the old people on Cape Cod is correct in ascribing the first creation of the Powder Hole to the first half of this century. We have witnessed its destruction.

Again, the point was located by the survey of Assistant P. C. F. West, of the Coast Survey, in 1868, 4,851 feet S. 5,266 feet W. of the same old light-house, showing an advance southwesterly of about 2,123 feet in twelve years, or about 175. feet per annum.

Finally, we have the plane-table sheet of Assistant C. H. Boyd, of the Coast Survey, executed with the intent to complete the history to the present time (June, 1886), and find the point 5,266 feet S. and 5,151 feet W. of the site of the Old Light-house, showing an advance of about 22½ feet per annum nearly south. The growth of the point is again slowing down, and Mr. Boyd's map shows that deposit has been arrested elsewhere *en route* from the north. It would seem that the material torn from the Chatham shore travels down the beach or near to it, and adds itself to the point of Monomoy in unequal masses at unequal intervals of time.

As far as we are advised, the sands move from the north under the action of the ground swell which sets on from the northeast. It is the same at this entrance to Vineyard Sound as at the entrances of Delaware and Chesapeake Bays—*the shoals protrude and advance from the north side.*

Of course, at all such entrances the flood tidal currents sweep in along the outside shores, and bear with them a great load of silt supplied by the breakers, so that the resultants are towards the bay, near the coast; but this movement (by currents) is usually just as conspicuous on one side as on the other of the entrance.

Mr. Boyd found the Shovelful Shoal showing a dry spot for two hours at low tide. This has been dry before, but our hydrographic sheets have usually given 1 foot at mean low tide. The summit of this shoal is now about 2,300 feet farther to the southwest than it was in 1853; but the point of Monomoy has gained upon it 877 feet. Of course, if this gain continues, a sudden annexation may be expected. It seems probable that this shoal advances more slowly than Monomoy Point, because in deeper water. The central point of the dry Shovelful is now S. 36° 41′ W. (true), from old light-house site, 9,617 feet.*

The discrepancies of the measures of Monomoy from land surveys cannot be attributed to any want of definition or to differences in the height of the tide. On sandy shores exposed to ocean waves the strand (*i. e.*, the belt left bare when the tide is out) is very narrow and of nearly uniform width for tides of equal range. This is often true, irrespective of the ocean depths in the neighborhood. It is quite otherwise as regards inside beaches—those along the margins of sheltered basins or harbors—where the strand is often broad and always irregular, because only the continuation of the *bed-slopes*. The point of Monomoy has always been bold or "steep-to," as the sailors say. Illustration No. 19 gives a comparison of Paul Pinkham's survey of 1784 with that of the Coast Survey of 1886.

Let us turn now from these measures of dry land to the hidden dangers that lie beneath the sea. These are *dunes* that creep upon the track of our commerce, and grow up in the channels, to become more and more sources of distress every year, and the most remarkable of these, although not the most dangerous, is the Handkerchief.

HANDKERCHIEF SHOAL.

From a glance at our most recent survey one would say that this shoal is shaped like a pear with stem downward. It is, in a very general sense, a sector-like figure with radius of 3¼ nautical miles and 36° flare. Closer examination, however, discovers that it is not symmetrical, but consists of three lobes, representing, as I think, three different periods of growth. The most northern lobe, which is the largest now, is the oldest. We find it upon Paul Pinkham's chart in the form of a horseshoe opening directly west. It was then about half the size of the present northern lobe as limited by the 12-foot curve, or less than a third of the whole shoal as now similarly limited.

The area of this shoal, as defined by the 18-foot curve, increased from 9,888,870 square yards in 1853 to 12,636,672 in 1875, and the southern point advanced into the sound 3,400 feet, or over one-half of a nautical mile (34 seconds of latitude). The bulk of this shoal in 1853 was 12,543,759 cubic yards; in 1875 it had increased to 19,175,835 cubic yards, and in this interval its center of gravity had moved 3,956 feet S. 2° 55′ E. (true).

* The old Light-house was 182 feet N. 46° 30′ W. (true) from present Light-house.

These recent changes of the Handkerchief Shoal can be thus concisely and confidently stated, because our figures are based upon very careful comparisons of soundings made for the Coast Survey by Lieut. Maxwell Woodhull, U. S. N., in 1853, Assistant F. D. Granger in 1874, and Lieut. R. D. Hitchcock, U. S. N., in 1875.

The sketches that accompany this report represent final conclusions from much discussion, in which Mr. H. F. Bothfeld has taken a laborious part as expert in such comparisons. Sketch No. 20 gives a graphical representation of the changes in the Handkerchief Shoal.

It is hoped in subsequent reports to complete this diagnosis, and to point out clearly—what now is but dimly seen—the dependence of these movements of the sands upon great cycles of the tides.

Very respectfully, yours,

HENRY MITCHELL,
Coast and Geodetic Survey.

Mr. F. M. THORN,
Superintendent Coast and Geodetic Survey.

REPORT CONCERNING THE EARLIEST TOPOGRAPHICAL SURVEY OF MONOMOY.

By CHARLES O. BOUTELLE, Assistant.

U. S. COAST AND GEODETIC SURVEY OFFICE,
Washington, D. C., June 16, 1886.

SIR: I return herewith the papers submitted by Assistant Mitchell on the subject of Monomoy Island, south of Chatham, Mass.

I recognize the smaller tracing, sent by Mr. H. F. Walling, as copied from a large manuscript map which I assisted in making. I also recognize it as a correct copy of a plane-table survey made by me on the island of Monomoy, in November, 1840. I checked the survey by several triangulation points upon the island, determined by me for temporary use, by the "three-point" method.

At the time of my survey the "Powder-hole" harbor, near the Light-house, was a place of resort for fishermen and a harbor of refuge for small vessels.

By spacing upon the tracing I find that the southernmost point of Monomoy Island, in November, 1840, was 2,475 feet, or 24″.4 S. and 3,836 feet W.—50″.5 of Monomoy Light. The Coast Survey position of the same light is given in Coast Survey Report for 1851, page 189, as latitude 41° 33′ 32″.79, longitude 69° 59′ 18″.98.

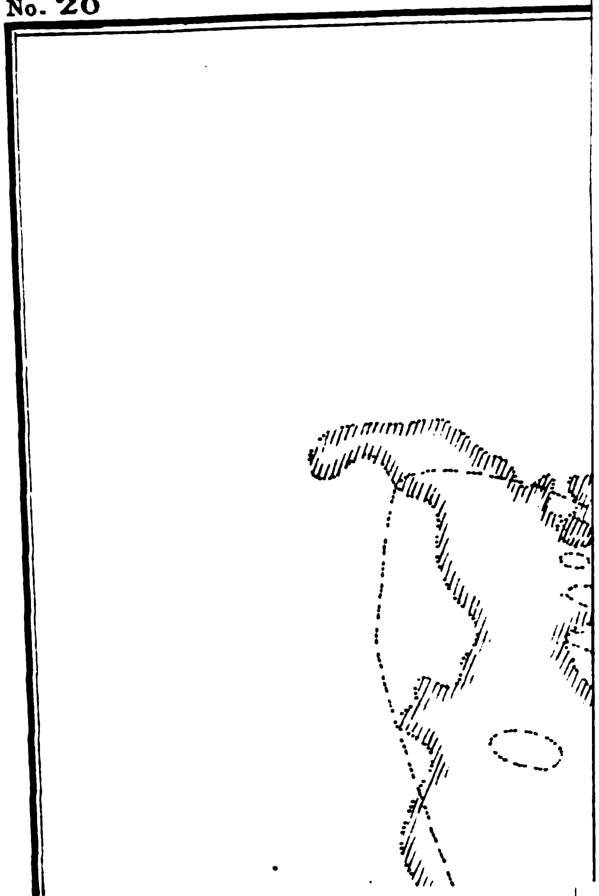
The "faint indication of a triangulation point" upon Mr. Walling's tracing is undoubtedly that of the Light-house. He gives the squares inclosing it. These count from the zero point of the section, and are four inches upon a side, or, upon the scale of 200 rods to an inch (1 : 39600), each side is 800 rods, or 13,200 feet, long.

In the printed tables of the Massachusetts Trigonometrical Survey, section v, page 71, Monomoy light-house is given as 202,380.37 feet south, and 191,375.31 feet east of the zero point of the section. The north side of the square inclosing the light is therefore the fifteenth south of the zero, or 13,200 × 15=198,000 feet south, and the east side is also the fifteenth, or 198,000 feet east of zero.

The position of the Light-house in the square is therefore 4,380.37 feet south of the north side, and 6,624.69 feet west of its east side.

These quantities spaced upon the tracing agree so closely with the station marked by Mr Walling as to assure its identity with the Light-house of 1840.

No. 20



The necessity for my survey of Monomoy Island arose from the grossly inaccurate character of the map of Chatham made by Mr. John G. Hale for the town authorities in 1831. This person was employed by contract with many towns in eastern Massachusetts to make maps which could be returned to the Secretary of State, under the act requiring each town to make and return a map of its territory upon a uniform scale of 100 rods to an inch.

Mr. Hale's maps were all very neatly drawn, and were all very inaccurate; many were only sketches without any survey.

So far as I can recollect, at this distance of time, I was informed that Mr. Hale never visited Monomoy Island, but copied some older map or chart. At any rate the case was so flagrant an evasion of the law that the selectmen of Chatham furnished me, at their expense, with men and transportation required to make the survey.

The large tracing sent by Mr. Walling represents Mr. Hale's map, now on record in the State House at Boston.

Yours, respectfully,

C. O. BOUTELLE,
Assistant, Coast and Geodetic Survey.

F. M. THORN,
Superintendent Coast and Geodetic Survey.

Appendix No. 9.—1886.

REPORT OF CHANGES IN THE SHORE-LINE AND BEACHES OF MARTHA'S VINEYARD, AS DERIVED FROM COMPARISONS OF RECENT WITH FORMER SURVEYS.

By HENRY L. WHITING, Assistant.

U. S. Coast and Geodetic Survey,
Boston, Mass., September, 1886.

Dear Sir: I present herewith a report of my recent resurveys of the shore-lines and beaches of Martha's Vineyard, more particularly in regard to the changes which have occurred since the first surveys were made, just forty years ago.

The changes along the southern shore of the Island give an interesting illustration of the action of what may be termed a "rolling beach," and the power of the ocean sea-dash upon a sandy shore to drive this material before it. The south shore of Martha's Vineyard is a cave, where little if any other force has operated. Its geographical position, so far beyond the trend of the main land, and its straight alignment, present an unobstructed front to the wave action. Although in occasional storms the breakers come upon the shore in oblique directions, the prevailing action of the sea-dash is normal to the shore. Even in gales from the southeast and southwest, after the force of the wind subsides, the breakers come in directly from the south. I witnessed some years ago after a heavy southeast gale a "roller," which I estimated to be a mile in length, break upon the shore in a single blow.

An examination of the original map upon which I have made the resurvey will give a better understanding of the nature and extent of the changes which have occurred than can be conveyed by a written description of them. Where the beaches have been low, particularly in front of the several ponds, the overshot of the sands has made a greater encroachment upon the ponds and marshes inside of the beach than occurs in the outer shore-line opposite. The general recedence of the shore line I should estimate at from 175 to 200 feet. At the crest of the summit of the bluff at Nashaquitsa Cliffs, which is about 150 feet in height, the maximum waste is about 220 feet. Opposite Chilmark Pond the maximum outer waste is about 180 feet, and the overshot of sands into the pond near the opening is about 525 feet. At Tisbury Great Pond the outside waste west and east of the inlet is, respectively, about 180 and 140 feet, while the corresponding encroachments upon the pond are, respectively, 680 and 480 feet. Quite a peculiar coincidence occurs in the present opening into Tisbury Pond with that of 1846, which is almost identical in location and extent, except that it is farther inward, while between the years 1860 and 1865 the opening was about three-fourths of a mile farther eastward. Most of the inlets of the southern ponds are opened artificially, for the purpose of improving the fisheries and to prevent the overflow of marshes by the fresher waters of the ponds. When once opened, the width and depth of the inlets are established and maintained according to the power and condition of the tides and the wave action of the ocean. They sometimes remain open for several months, and again are closed by the first heavy storm.

The most considerable movement of the entire beach occurs along the front of Great Herring Pond, in Edgartown, where the whole mass of the beach has been driven in upon the former waters

of the pond a distance about equal to twice its width. As will be seen upon the map the overshot of sands has entirely obliterated Craxtuckett Pond and a smaller one west of Great Herring Pond, and in one instance changed what was a former cove into a separate pond.

I would again briefly allude to the difficulty of making an accurate resurvey of the south shore of Martha's Vineyard, in consequence of the entire loss of former points. The mere linear extent of shore-line surveyed gives no adequate measure of the work involved.

The survey of the new opening into Edgartown Harbor and Cotamy Bay and the shores of Chappaquiddick Island, should, I suppose, be classed as an original survey. It is on a new projection and not connected with former work. The locality of the work, except along the northerly shore of Chappaquiddick and at Cape Poge, is beyond the immediate control of the only group of triangulation points upon the sheet (Edgartown Spire and Light-House, Cope Poge Light-House, and Sampson's Hill). I wish, however, to report the very excellent character of the projection made by Mr. Charles Junken and sent to me for this work. I found it so accurate that the most remote determinations from the base points at the southeasterly part of the sheet were effected without any perceptible error. I have marked upon the sheet a number of intermediate points which I have determined for use in the detailed survey, mainly house chimneys, which will save much labor in the event of future resurveys.

I had not the original map of my survey of 1846 of the eastern part of Chappaquiddick and Cape Poge, by which to make comparison of results and report upon the changes. This can, of course, be done at the office. I would call attention, however, to the point of Cape Poge where great waste has occurred. The summit of the sandy bank or bluff nearest to the Light-House is now within about 45 feet of its foundation and wasting rapidly. Some thirty years ago or more the foot of this bank was protected by a rip-rap of stone. The line of this ridge of stone can be seen under water from the top of the bank, I judged from 500 to 600 feet beyond the present shore-line. There is indication of overflow along the beach opposite the two easterly coves of Cape Poge Pond, which may have been of sufficient force and range to affect the outlines of the coves themselves. How far the strong tidal currents through Muskeget channel have affected the easterly beach of Chappaquiddick I am unable, for the reason stated, to report. At the extreme southeasterly point of the island (Wasque Point), or just south and west of the point, the tendency seems to be to maintain a remarkable uniformity of position. Slight changes, forming waves in the outer line of the beach, occur with almost every storm, but the general outline of the point is in much the same geographical position it was forty years ago.

A feature of interest and value as a means of shelter and protection in this exposed fishing-ground is the increase, in size and elevation above high tide, of Skiffs Island, which for the past twenty years has been little more than a shoal dry at low water. Whether its present changed condition is due to the influence of the new currents through the new opening is a question which would require quite elaborate observation to determine. At the time of my former survey "Skiffs Island" was merely a shoal covered at high tide. Its condition and the rough water and "rips" around it made it impractical to determine it as a topographic feature. Its location on the published charts of the Survey is, I believe, from hydrographic data. In connection with my present survey I thought it important to determine its position and outline more accurately. I did not make instrumental stations upon it, but put signals on the salient points and determined them from shore stations. The geographical position of the Island falls off the present sheet, but I have transferred it one minute in longitude west from its true position. The survey was made on August 15, which was the first of many days when a landing could be favorably made. The Island is about southeast from Wasque Point and distant from shore to shore about 1½ miles. At the time of the survey it was about 1,200 feet in length—north and south—with a greatest width, east and west, of about 290 feet and contained an area of about 4½ acres. Probably for the first time in the last fifty years beach weeds and grasses are taking root and growing upon it.

The new opening through Cotamy beach, so called, occurred on the night of January 9–10, 1886. After a gale from ENE. the wind shifted to WSW., still blowing a gale. The west beach, as the portion west of the opening is now designated, was quite low before this gale occurred, and after the shift of wind the whole beach, in long-shore phrase, was a "breaker." A very high tide—one of the highest since the Minot's Ledge gale—accompanied this storm. The general opinion is

that with the turn of the tide the opening was first made by the outward or southerly current. As soon as the beach could be visited the opening was already, by estimation, about 100 yards in width. On July 1 it was about 1,200 feet.

The present survey of the inlet was made on July 1, and the position of the sandy points on either side of it as then determined, place the opening about half its width east of the position of the former opening as determined by the survey of 1856. The width of the present inlet, as will be seen by comparison of the two surveys, is nearly the same. [See illustration No. 21.] There is not much change in the general position of the beach, but the easterly point of the present opening is farther within the bay (northward) than at any previous time. The changes of filling up, by wind and sea, in the site of the last opening, before it closed, along its pathway between the fast land of Chappaquiddick and the former outer beach, are exhibited by the details of the map.

Contrary to the usual action of the inlets and openings on the south side of Martha's Vineyard, and particularly those through Cotamy Beach, the resultants of the moving sands thus far with the new inlet have been *westward*. This, however, will probably prove to be but a temporary movement, and eventually the opening, as all previous ones have done, will work *eastward*. There are present conditions of the beach, however, which may retard this movement. This influence, if effective, will be due to the comparatively small amount of material in the west beach, which is unusually low. One of the forces which prevail in causing the easterly movement of the opening is the encroachment of the west point or chop upon its channel, and, by contracting it, causing a corresponding waste or cutting away on the east point or chop. Formerly the west beach contained quite high sand hills and dunes, which supplied material for the extension of the water-point. The high sand bank which existed in 1871 was probably one of the causes which tended to fill up the artificial cut made by General Warren.

The tidal currents through the inlet, through the narrows of Cotamy Bay and through Edgartown Harbor, are now very strong. I am unable to state the exact velocity, but it has had power to increase the depth of water along the front of the town and about the wharves. The currents are also effecting change in the position and depth of the point of Chappaquiddick, opposite the town. They also affect the manœuvering of vessels, which now do not like to anchor above Chappaquiddick Point. The fishermen state that the scour of those currents is injuring the clam and quahaug grounds, which are of much local value. I have endeavored to ascertain whether the tidal currents through the harbor were stronger now than when the inlet of 1856 was open. From such facts as I could gather, however, they seem to be of about the same force. In 1856 a whale ship lying at the inner wharf was torn from her moorings and carried eastward with the tide until her anchors were let go.

That these strong currents must produce changes in the physical condition of the harbor seems self-evident. The very peculiar tidal phenomena connected with it makes the study of the subject one of special interest. Comparing the time the present inlet has been open, about eight months, with the eighteen or twenty years of less effective action since the former inlet closed, the probabilities are that the harbor channels and shoals are still in a transition state. During the next spring or summer it may be desirable to ascertain, by a hydrographic survey, the degree of change which has taken place, and in what way the change of regimen affects the quality of the harbor.

I append a notice from the local paper, the Vineyard Gazette, relating to the opening of the new inlet.

Very respectfully submitted.

HENRY L. WHITING, *Assistant.*

Mr. F. M. THORN,
Superintendent Coast and Geodetic Survey.

[Vineyard Gazette, Edgartown, January 15, 1886.]

One of the results of Saturday's gale was the breaking through of the south beach near the entrance to Cotamy Bay, the first effectual opening from the harbor directly to the ocean in twenty

years. The opening is reported to be 100 feet wide and 5 or 6 feet in depth, and it is believed will be likely to stand for a number of years, although there are those who dissent from this opinion. Assuming the permanency of the opening, however, its importance can hardly be overestimated. The long voyage around Cape Poge, with its attendant risks and exposure, and the long day required for a few hours' fishing, can be discontinued, and instead thereof will be substituted the safe and easy run down the harbor, with two chances a day for those who desire it. Summer visitors will enjoy the easy access to the fishing-grounds now afforded, and the sojourners at Katama especially, who have had heretofore to sail nearly around the island of Chappaquiddick to catch a bluefish, but who can now accomplish their purpose after a half-hour's run, will find the change a most agreeable one. With proper legislation on the seining question the new opening ought in all respects, with the possible exception of the quahaug fishery, to operate to the decided advantage of the town.

Appendix No. 10.—1886.

A REPORT ON THE DELTA OF THE DELAWARE.

By HENRY MITCHELL, Assistant.

COAST AND GEODETIC SURVEY OFFICE, *June* 25, 1886.

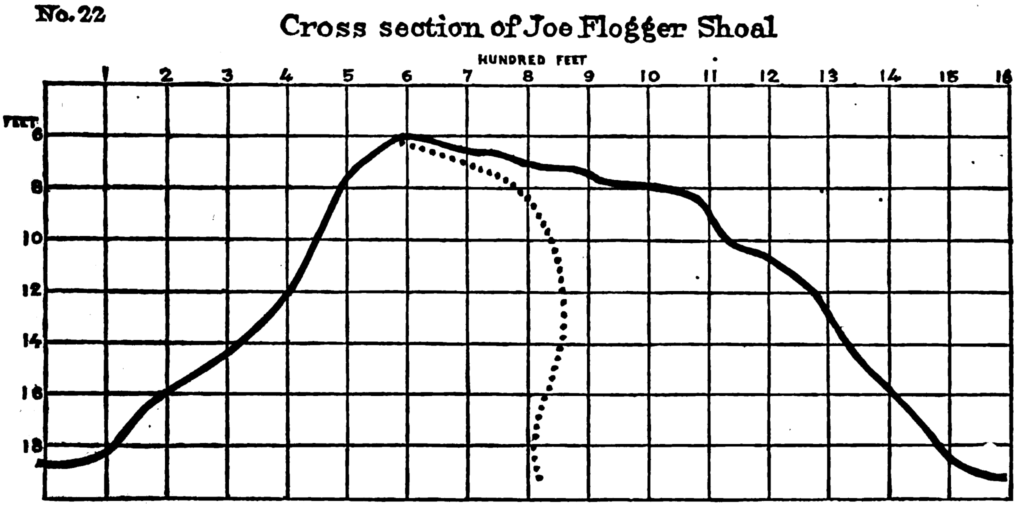
Joe Flogger Shoal.—This shoal forms the central prong in the submerged delta of the Delaware. It is a mole of sand protruding from the mouth of the river into the bay, with a fair way or pass on either side. It is over 13 nautical miles long, but only 2,000 feet wide, in the average, at the base (18 feet below the plane of low-water spring tides).* It has an irregular and variable summit, with two remarkable sags or sloughs.

We have two excellent surveys of this shoal, the first made in 1841–'43 by Lieut. George S. Blake and others, the second in 1882–'83 by Marindin, Mansfield, and Winslow. The case admitted of a simpler method than usual, and may be briefly stated thus:

METHOD OF COMPARING OLD AND NEW SURVEYS.

We have already referred to Joe Flogger Shoal as a long mole extending from the mouth of Delaware River into Delaware Bay. We have compared the dimensions of this mole for the different dates precisely as if it were an artificial structure needing repair. We have plotted the profile of its crest with a plan of its location as a first essay (see Diagram A); we have then plotted a profile of its mean depth, its location, and its width, and we have done this for each date, placing the results side by side (Diagram B). The mean depth is the mean of the soundings from the 18-foot contour on one side to the same contour on the other, and the location is that of the axis of each cross-section. That there may be no misunderstanding of this statement, the manner of determining the axis or the axial point in each cross-section is illustrated in the following diagram:

No. 22



* We have used "18 feet L. W." because this contour has been most carefully traced on the original sheets, but we should have preferred to adhere to our higher base plane of 18.6 below mean level (half tide). See Annual Report, 1883, Appendix No. 8.

The dotted line in above diagram bisects all the chords of the cross section, and the mean of all the points of bisection falls at 7.8 on the horizontal scale, *i. e.*, at $\frac{7.8}{18}$ of the base of the figure (18 feet at low tide) lies the axis of the shoal at this point.

Having plotted the location, crest, width, mean depth, and sectional area, we have formulated these for equal distances along our base. (See Tables I and II.)

In locating this base upon the different projections Mr. Boyd has placed its zero, or origin of ordinates, in longitude 75° 25′ W., latitude 39° 16′ N. on the hydrographic sheet of 1841, and in longitude 75° 22′ 15″, latitude 39° 16′ 06″ on the hydrographic sheet of 1882—these locations being identical in nature.

RESULTS OF THE COMPARISONS.

The first comparison was made for the location and height of the summit ridge, *i. e.*, the crest of the shoal.

This ridge has lost nearly a mile of length at the upper end, and it has dropped or worn down about 1½ feet in the forty years elapsed between the two surveys.

This summit ridge has preserved the old alignment pretty well, except that the slough at the fifth mile amounts almost to a break now, and the break at the tenth and eleventh miles has shifted up-stream. (See Table No. I and diagram A.*)

The highest part of the summit ridge was about midway of its length in 1841, but in the last survey it is found near the southern end. The great slough has shifted northward over one nautical mile without any change of depth; it is, however, much narrower.

The second comparison was made for the location of the axis of the shoal, for the mean height, and for the base width; the plane of reference being low water of spring tides or one-half foot below mean low water.† (See the second set of tables attached to this report and diagram B.*)

Leaving out of consideration certain low and indefinite portions of the shoal, we may assert that its axis lies now where it did in 1841, but its length has diminished about 7 per cent., its width 20 per cent., and its elevation of axis 11 per cent. These changes appear also in other prongs of the delta, such as Cross Ledge, &c., where loss of elevation is still more considerable. A glance at the diagram B, however, shows that the heavier portions of the shoal have maintained nearly the same elevations in the average. Midway of the length of the shoal (11,000 to 15,500 meters of our table), where the heaviest portion of the Joe Flogger is now found, the mean elevation has remained almost exactly the same for the axis, although the summit has lost 1 foot in the average and 3 feet at greatest. The width at the base has not increased, but the crest is flattened as if by the wash of steam vessels.

The volume of sand composing Joe Flogger Shoal has been reduced, according to these tables, 30 per cent., if we count the original length, or if we count only the present length and its corresponding portion of the old shoal, we have a loss of about 27 per cent. No possible error in plane of reference can account for this, nor do we find adequate evidence of submergence; but upon these shoals and upon some portions of the shores there has been waste.

While the loss of length in Joe Flogger Shoal is mostly at the upper end, the wear in the lower half of the present shoal seems to be greater than in the upper. Confining ourselves to the present length, we find that the cross-section of the upper half lost, since 1842, 4,334 square feet, while the lower half lost 5,132 square feet, *i. e.*, 18 per cent. more.

For that portion of the old shoal that has been lost, *i. e.*, the first mile of Table No. I, we have examined the new survey and find a ridge which marks the ruin of the old shoal. This ridge has an average depth upon it of 23½ feet, while in 1842–'43 the average depth was about 13 feet. The Joe Flogger lost, then, between 1842–'43 and 1882–'83, a mile (or more nearly 1,800 meters) from its upper end, and in this mile there was an average deepening of 10 feet, *i. e.*, the summit fell or washed off, so as to lose 10 feet in elevation for over a mile in length.

* The diagrams are omitted because of their great length. They are plottings on profile paper of the elements of the tables which follow.

† The survey of 1841–'43 was reduced to the plane of low-water spring tides, and the contours having been very carefully drawn in when the survey was made we did not dare to alter them, so we adjusted the new survey to this lower plane of reference.

The valuable channels on either side of Joe Flogger Shoal have not suffered. On the contrary, the *thalweg* depths have increased; they, too, have been scoured down.

In the Blake Channel, which lies westward of the shoal, the first half of the distance (13,000 meters from the head of the channel), the deepening is only 0.2 foot, or essentially nothing; but for the second half (13,000 to 26,600 meters) the deepening is nearly 3¾ feet. In the channel on the other side of Joe Flogger, *i. e.*, in the main-ship-channel, the *thalweg* has deepened almost the entire length, and in the average 3¼ feet very nearly. The minimum depth in either of these channels has not, perhaps, essentially changed, although the more numerous soundings in the later survey discover more water over the shallower reaches than would appear from the old work. (See Tables III and IV.)

We are much indebted to Assistant C. H. Boyd, Mr. W. B. Fairfield, and Mr. C. J. Meade, who have done most of the work on these comparisons. The first named gave but little time, being busy on the review of accounts, but his work was of good quality, being the proper adjustment of projections and the like. Mr. Fairfield made the tables and Mr. Meade the diagrams.

Very respectfully submitted.

HENRY MITCHELL, *Assistant.*

Mr. F. M. THORN,
Superintendent Coast and Geodetic Survey.

TABLE I.—*Joe Flogger Shoal, comparative dimensions.*

Distance on base.	Location of summit.		Difference.	Height of summit.		Difference.
	1842.	1883.		1842.	1883.	
Meters.	*Meters.*	*Meters.*	*Meters.*	*Feet.*	*Feet.*	*Feet.*
0	320	-------	-------	0	------	-------
200	440	-------	-------	1.0	------	-------
400	520	-------	-------	1.0	------	-------
600	600	-------	-------	1.4	------	-------
800	680	-------	-------	5.8	------	-------
1,000	680	-------	-------	7.0	------	-------
1,200	720	-------	-------	7.0	------	-------
1,400	720	-------	-------	7.0	------	-------
1,600	720	-------	-------	7.0	------	-------
1,800	720	640	+ 80	6.6	0.0	+6.6
2,000	720	640	+ 80	7.8	2.0	+5.8
2,200	720	720	00	7.6	3.0	+4.6
2,400	720	760	− 40	8.0	5.0	+3.0
2,600	680	800	−120	8.0	6.0	+2.0
2,800	720	720	00	8.6	7.0	+1.6
3,000	720	720	00	8.8	7.6	+1.2
3,200	720	760	− 40	9.0	8.6	+0.4
3,400	720	760	− 40	8.2	5.0	+3.2
3,600	680	800	−120	8.0	7.0	+1.0
3,800	720	800	− 80	9.0	7.6	+1.4
4,000	760	800	− 40	9.0	7.4	+1.6
4,200	720	800	− 80	10.0	6.4	+3.6
4,400	680	800	−120	9.2	6.2	+3.0
4,600	720	800	− 80	8.4	6.2	+2.2

TABLE I.—*Joe Flogger Shoal, comparative dimensions*—Continued.

Distance on base.	Location of summit.		Difference.	Height of summit.		Difference.
	1842.	1883.		1842.	1883.	
Meters.	*Meters.*	*Meters.*	*Meters.*	*Feet.*	*Feet.*	*Feet.*
4,800	720	800	— 80	8.2	6.2	+2.0
5,000	760	800	— 40	8.0	7.0	+1.0
5,200	760	800	— 40	8.0	6.2	+1.8
5,400	720	800	— 80	7.0	6.0	+1.0
5,600	720	800	— 80	7.8	6.0	+1.8
5,800	720	760	— 40	8.8	6.0	+2.8
6,000	760	760	00	9.8	6.4	+3.4
6,200	720	760	— 40	10.0	7.4	+2.6
6,400	680	760	— 80	12.0	8.4	+3.6
6,600	680	720	— 40	11.2	8.6	+2.6
6,800	680	760	— 80	11.0	8.8	+2.2
7,000	680	720	— 40	10.0	9.0	+1.0
7,200	680	760	— 80	11.0	9.4	+1.6
7,400	720	760	— 40	12.0	10.0	+2.0
7,600	760	720	+ 40	12.0	10.4	+1.6
7,800	760	720	+ 40	11.0	9.4	+1.6
8,000	760	760	00	12.0	9.0	+3.0
8,200	800	880	— 80	13.0	7.8	+5.2
8,400	840	920	— 80	12.0	6.8	+5.2
8,600	920	1,000	— 80	9.0	5.4	+3.6
8,800	1,000	1,080	— 80	11.0	3.4	+7.6
9,000	1,040	1,200	—160	10.0	4.0	+6.0
9,200	1,040	1,360	—320	10.0	6.4	+3.6
9,400	1,080	1,320	—240	10.8	7.0	+3.8
9,600	1,080	1,280	—200	12.0	8.2	+3.8
9,800	1,080	1,200	—120	12.0	8.6	+3.4
10,000	1,080	1,160	— 80	13.0	9.4	+3.6
10,200	1,120	1,160	— 40	13.8	10.4	+3.4
10,400	1,120	1,160	— 40	14.0	10.8	+3.2
10,600	1,120	1,160	— 40	14.2	12.0	+2.2
10,800	1,120	1,120	00	15.0	11.6	+3.4
11,000	1,120	1,120	00	15.0	11.4	+3.6
11,200	1,160	1,120	+ 40	15.0	12.0	+3.0
11,400	1,160	1,120	+ 40	16.0	12.4	+3.6
11,600	1,160	1,120	+ 40	15.0	12.0	+3.0
11,800	1,080	1,040	+ 40	14.0	12.0	+2.0
12,000	1,000	1,000	00	15.4	13.0	+2.4
12,200	920	960	— 40	14.2	12.8	+1.4
12,400	840	880	— 40	15.0	12.8	+2.2
12,600	840	840	00	14.8	12.2	+2.6
12,800	800	760	+ 40	14.0	13.0	+1.0
13,000	840	720	+120	15.0	13.4	+1.6
13,200	800	720	+ 80	15.0	14.2	+0.8
13,400	760	760	00	15.0	14.2	+0.8

TABLE I.—*Joe Flogger Shoal, comparative dimensions*—Continued.

Distance on base.	Location of summit.		Difference.	Height of summit.		Difference.
	1842.	1883.		1842.	1883.	
Meters.	*Meters.*	*Meters.*	*Meters.*	*Feet.*	*Feet.*	*Feet.*
13,600	720	760	— 40	15.2	14.4	+0.8
13,800	680	760	— 80	16.0	14.6	+1.4
14,000	640	760	—120	15.0	14.0	+1.0
14,200	640	800	—160	15.0	14.0	+1.0
14,400	640	800	—160	15.0	13.8	+1.2
14,600	680	840	—160	14.0	13.2	+0.8
14,800	680	920	—240	14.0	13.0	+1.0
15,000	720	960	—240	14.0	13.2	+0.8
15,200	720	1,000	—280	14.0	13.4	+0.6
15,400	760	1,040	—280	14.0	13.4	+0.6
15,600	760	1,080	—320	16.0	13.4	+2.6
15,800	760	1,120	—360	14.0	12.0	+2.0
16,000	760	1,120	—360	14.0	11.8	+2.2
16,200	760	1,120	—360	15.0	11.6	+3.4
16,400	760	1,120	—360	15.0	11.6	+3.4
16,600	840	1,160	—320	16.0	10.4	+5.6
16,800	840	1,200	—360	16.0	10.4	+5.6
17,000	840	1,240	—400	16.0	10.4	+5.6
17,200	840	1,240	—400	14.0	8.2	+5.8
17,400	800	1,240	—440	14.0	8.2	+5.8
17,600	800	1,200	—400	13.0	6.8	+6.2
17,800	840	1,160	—320	13.0	6.2	+6.8
18,000	840	1,160	—320	12.0	2.4	+9.6
18,200	800	1,200	—400	12.0	2.4	+9.6
18,400	720	1,320	—600	10.0	2.4	+7.6
18,600	760	1,440	—680	10.0	3.0	+7.0
18,800	760	1,480	—720	8.0	3.0	+5.0
19,000	720	1,440	—720	6.0	4.6	+1.4
19,200	720	1,400	—720	5.0	6.0	—1.0
19,400	760	1,360	—600	4.6	6.0	—1.4
19,600	840	1,360	—520	4.6	6.4	—1.8
19,800	880	1,320	—440	5.8	7.6	—1.8
20,000	920	1,320	—400	4.0	9.4	—5.4
20,200	1,040	1,320	—280	4.0	10.0	—6.0
20,400	1,080	1,320	—240	3.0	10.0	—7.0
20,600	960	1,280	—320	3.0	10.6	—7.6
20,800	1,040	1,240	—200	3.2	10.6	—7.4
21,000	1,080	1,240	—160	4.0	11.0	—7.0
21,200	1,080	1,240	—160	5.0	10.6	—5.6
21,400	1,040	1,240	—200	6.0	10.4	—4.4
21,600	1,040	1,200	—160	7.0	11.0	—4.0
21,800	1,120	1,240	—120	7.0	10.4	—3.4
22,000	1,120	1,240	—120	10.0	11.0	—1.0
22,200	1,040	1,240	—200	10.0	10.6	—0.6

TABLE I.—*Joe Flogger Shoal, comparative dimensions*—Continued.

Distance on base.	Location of summit.		Difference.	Height of summit.		Difference.
	1842.	1883.		1842.	1883.	
Meters.	*Meters.*	*Meters.*	*Meters.*	*Feet.*	*Feet.*	*Feet.*
22, 400	1, 080	1, 200	—140	11. 0	10. 6	+0. 4
22, 600	1, 120	1, 120	00	11. 0	13. 0	—2. 0
22, 800	1, 120	1, 080	+ 40	12. 0	13. 0	—1. 0
23, 000	1, 040	1, 040	00	12. 0	15. 0	—3. 0
23, 200	920	1, 040	—120	12. 0	13. 0	—1. 0
23, 400	920	1, 040	—120	13. 0	12. 8	+0. 2
23, 600	880	1, 000	—120	13. 2	13. 0	+0. 2
23, 800	840	1, 000	—160	13. 0	13. 0	0. 0
24, 000	840	1, 000	—160	13. 0	12. 0	+1. 0
24, 200	800	1, 000	—200	14. 0	10. 8	+3. 2
24, 400	800	1, 000	—200	14. 0	11. 0	+3. 0
24, 600	880	1, 000	—120	14. 0	8. 0	+ 6. 0
24, 800	920	960	— 40	15. 0	8. 0	+ 7. 0
25, 000	1, 000	960	+ 40	15. 0	7. 0	+ 8. 0
25, 200	960	960	00	13. 0	6. 0	+7. 0
25, 400	920	960	— 40	12. 0	6. 0	+ 6. 0
25, 600	920	960	— 40	9. 0	5. 0	+4. 0
25, 800	920	1, 040	—120	6. 0	4. 0	+2. 0
26, 000	960	1, 080	—120	5. 0	3. 0	+2. 0
26, 200	1, 000	1, 040	— 40	2. 0	1. 4	+ 0. 6
26, 400	1, 040	....	....	1. 0	......	....
26, 600	1, 120	....	......	0. 0	....	....
Mean*	....	....	+ 150	......	9. 0	+ 2. 0 — . 5
Mean	....	....	....	10. 4	......	1. 5

*These means are taken from the present length of the shoals.

The second set applies to original length of shoal. In this table the heights for 1883 must be corrected by adding 0.5 feet to reduce to same plane—low water spring tides.

TABLE II.—*Joe Flogger Shoal, comparative dimensions.*

Distance on base.	Location.		Difference.	Width.		Difference.	Mean elevation.		Difference.	Area of cross-section.		Difference.
	1842.	1883.		1842.	1883.		1842.	1883.		1842.	1883.	
Meters.	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Sq. feet.*
0	360	....	....	0	....	....	0	......	....	0	....	....
200	440	....	....	120	....	....	1. 2	......	....	473	....	....
400	520	....	....	200	....	....	2. 0	......	....	1, 312	....	....
600	600	....	....	280	......	....	2. 9	......	....	2, 665	....	....
800	680	....	....	320	....	....	3. 7	......	....	3, 885	....	....
1, 000	720	....	....	400	....	....	4. 1	......	....	5, 383	....	....
1, 200	720	....	....	440	....	....	3. 9	......	....	5, 632	....	....

TABLE II.—*Joe Flogger Shoal, comparative dimensions*—Continued.

Distance on base.	Location.		Difference.	Width.		Difference.	Mean elevation.		Difference.	Area of cross-section.		Difference.
	1842.	1883.		1842.	1883.		1842.	1883.		1842.	1883.	
Meters.	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Sq. feet.*
1,400	720	------	------	440	------	------	4.1	------	------	5,920	------	------
1,600	800	------	------	440	------	------	4.0	------	------	5,776	------	------
1,800	800	640	+160	520	120	+400	4.3	0.8	+3.5	7,323	315	+ 7,008
2,000	760	680	+ 80	680	240	+440	5.4	1.9	+3.5	12,047	1,495	+10,552
2,200	760	720	+ 40	760	320	+440	6.0	2.6	+3.4	14,958	2,730	+12,228
2,400	760	800	— 40	720	440	+280	5.0	3.0	+2.0	11,810	4,332	+ 7,478
2,600	760	800	— 40	720	520	+200	4.2	3.8	+0.4	9,920	6,471	+ 3,449
2,800	720	800	— 80	720	600	+120	3.8	4.0	—0.2	8,976	7,872	+ 1,104
3,000	720	800	— 80	720	520	+200	4.1	3.6	+0.5	9,684	6,131	+ 3,553
3,200	720	800	— 80	720	440	+280	4.1	4.1	0.0	9,684	5,920	+ 3,764
3,400	700	800	— 40	720	440	+280	4.1	4.5	—0.4	9,684	6,498	+ 3,186
3,600	840	800	+ 40	720	400	+320	4.1	3.9	+0.2	9,684	5,121	+ 4,563
3,800	840	800	+ 40	680	400	+240	4.0	3.8	+0.2	8,924	4,989	+ 3,935
4,000	880	800	+ 80	680	400	+240	4.0	3.6	+0.4	8,924	4,727	+ 4,197
4,200	840	840	00	760	400	+360	4.0	3.5	+0.5	9,972	4,596	+ 5,376
4,400	840	840	00	800	400	+400	4.1	3.5	+0.6	10,763	4,596	+ 6,167
4,600	800	840	— 40	800	400	+400	4.0	3.3	+0.7	10,500	4,333	+ 6,167
4,800	840	840	00	840	400	+440	4.0	2.9	+1.1	11,024	3,808	+ 7,216
5,000	840	800	+ 40	840	360	+480	3.9	3.6	+0.3	10,748	4,252	+ 6,496
5,200	840	800	+ 40	760	360	+400	4.1	3.9	+0.2	10,221	4,606	+ 5,615
5,400	840	800	+ 40	760	400	+360	4.5	3.7	+0.8	11,219	4,858	+ 6,361
5,600	800	760	+ 40	760	400	+360	4.8	3.5	+1.3	11,966	4,596	+ 7,370
5,800	760	720	+ 40	760	440	+320	5.0	3.5	+1.5	12,465	5,054	+ 7,411
6,000	800	760	+ 40	760	440	+320	5.0	3.5	+1.5	12,465	5,054	+ 7,411
6,200	800	760	+ 40	840	440	+400	5.0	3.1	+1.9	13,780	4,476	+ 9,304
6,400	760	720	+ 40	840	480	+360	4.9	3.7	+1.2	13,504	5,828	+ 7,676
6,600	800	760	+ 40	840	560	+280	5.3	4.7	+0.6	14,607	8,634	+ 5,973
6,800	840	800	+ 40	840	640	+200	5.6	5.0	+0.6	15,434	10,500	+ 4,934
7,000	840	800	+ 40	800	640	+160	5.9	5.2	+0.7	15,488	10,920	+ 4,568
7,200	840	800	+ 40	760	680	+ 80	6.6	6.5	+0.1	16,454	14,502	+ 1,952
7,400	800	800	00	760	680	+ 80	7.1	6.5	+0.6	17,700	14,502	+ 3,198
7,600	800	800	00	960	880	+ 80	6.7	6.6	+0.1	21,105	19,054	+ 2,051
7,800	840	800	+ 40	1,160	1,120	+ 40	6.0	5.8	+0.2	22,836	21,315	+ 1,521
8,000	880	840	+ 40	1,200	1,200	00	5.2	4.1	+1.1	20,472	16,142	+ 4,330
8,200	960	880	+ 80	1,240	1,280	— 40	5.1	4.0	+1.1	20,747	16,800	+ 3,947
8,400	1,000	960	+ 40	1,240	1,280	— 40	5.0	3.8	+1.2	20,340	15,960	+ 4,380
8,600	1,040	1,080	— 40	1,200	1,280	— 80	4.9	2.5	+2.4	19,291	10,500	+ 8,791
8,800	1,040	1,200	—160	1,200	1,280	— 80	5.1	3.0	+2.1	20,079	12,600	+ 7,479
9,000	1,040	1,240	—200	1,160	1,320	—160	5.1	3.7	+1.4	19,411	16,025	+ 3,386
9,200	1,080	1,200	—120	1,080	1,160	— 80	5.1	4.3	+0.8	18,069	16,366	+ 1,703
9,400	1,120	1,040	+ 80	1,040	920	+120	5.4	4.9	+0.5	18,425	14,788	+ 3,637
9,600	1,160	1,120	+ 40	960	760	+200	5.9	5.5	+0.4	18,585	13,712	+ 4,873
9,800	1,160	1,280	—120	880	720	+160	6.2	6.6	—0.4	17,899	15,589	+ 2,310
10,000	1,160	1,240	— 80	800	720	+ 80	6.4	7.2	—0.8	16,800	17,006	— 206
10,200	1,200	1,240	— 40	760	680	+ 80	6.9	7.7	—0.8	17,202	17,179	+ 23

TABLE II.—*Joe Flogger Shoal, comparative dimensions*—Continued.

Distance on base.	Location.		Differ-ence.	Width.		Differ-ence.	Mean eleva-tion.		Differ-ence.	Area of cross section.		Differ-ence.
	1842.	1883.		1842.	1883.		1842.	1883.		1842.	1883.	
Meters.	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Sq. feet.*
10,400	1,200	1,200	00	760	720	+ 40	7.3	8.0	−0.7	18,199	18,896	− 697
10,600	1,240	1,120	+120	760	720	+ 40	7.6	8.2	−0.6	18,947	19,368	− 421
10,800	1,200	1,160	+ 40	760	720	+ 40	8.0	8.4	−0.4	19,944	19,840	+ 104
11,000	1,160	1,240	− 80	760	720	+ 40	8.8	8.6	+0.2	21,938	20,313	+ 1,625
11,200	1,120	1,200	80	800	760	+ 40	9.6	8.7	+0.9	25,200	21,689	+ 3,511
11,400	1,080	1,160	− 80	800	760	+ 40	10.1	9.0	+1.1	26,513	22,437	+ 4,076
11,600	1,040	1,160	−120	840	760	+ 80	10.2	9.3	+0.9	28,111	23,185	+ 4,926
11,800	1,040	1,080	− 40	840	760	+ 80	10.0	9.5	+0.5	27,560	23,684	+ 3,876
12,000	1,080	1,040	+ 40	840	760	+ 80	10.0	9.1	+0.9	27,560	22,686	+ 4,874
12,200	1,080	960	+120	840	760	+ 80	9.9	9.3	+0.6	27,284	23,185	+ 4,099
12,400	960	1,000	− 40	840	760	+ 80	9.8	9.1	+0.7	27,009	22,686	+ 4,323
12,600	960	880	+ 80	840	760	+ 80	9.3	8.5	+0.8	25,631	21,190	+ 4,441
12,800	960	880	+ 80	840	760	+ 80	8.8	8.5	+0.3	24,253	21,190	+ 3,063
13,000	880	840	+ 40	840	720	+120	7.7	8.9	−1.2	21,221	21,022	+ 199
13,200	840	840	00	840	720	+120	7.5	8.7	−1.2	20,670	20,549	+ 121
13,400	800	840	− 40	840	720	+120	7.2	8.6	−1.4	19,843	20,313	− 470
13,600	720	840	−120	880	680	+200	8.0	8.9	−0.9	23,096	19,856	+ 3,240
13,800	680	880	−200	960	680	+280	8.9	9.4	−0.5	28,035	20,971	+ 7,064
14,000	600	880	−280	1,000	640	+360	9.1	9.3	−0.2	29,857	19,530	+10,327
14,200	520	920	−400	960	640	+320	9.0	8.6	+0.4	28,350	18,060	+10,290
14,400	520	960	−440	960	640	+320	8.9	8.0	+0.9	28,035	16,800	+11,235
14,600	560	1,000	−440	1,000	600	+400	8.4	8.4	0.0	27,560	16,531	+11,029
14,800	560	1,000	−440	1,000	600	+400	7.7	8.3	−0.6	25,264	16,334	+ 8,930
15,000	640	1,000	−360	1,040	600	+440	7.0	8.0	−1.0	23,884	15,744	+ 8,140
15,200	640	1,040	−400	1,000	640	+360	6.9	8.3	−1.4	22,639	17,430	+ 5,209
15,400	680	1,040	−360	1,000	640	+360	7.3	8.3	−1.0	23,951	17,430	+ 6,521
15,600	680	1,080	−400	960	640	+320	7.5	7.5	0.0	23,625	15,750	+ 7,875
15,800	720	1,120	−400	880	640	+240	8.2	7.1	+1.1	23,673	14,910	+ 8,763
16,000	720	1,120	−400	800	680	+120	9.1	7.5	+1.6	23,888	16,732	+ 7,156
16,200	760	1,120	−360	760	680	+ 80	10.0	6.9	+3.1	24,930	15,394	+ 9,536
16,400	800	1,120	−320	760	680	+ 80	10.0	6.6	+3.4	24,930	14,725	+10,205
16,600	800	1,160	−360	760	600	+160	9.7	6.9	+2.8	24,182	13,579	+10,603
16,800	840	1,200	−360	800	560	+240	9.4	6.6	+2.8	24,675	12,124	+12,551
17,000	880	1,200	−340	840	480	+360	9.1	5.4	+3.7	25,080	8,505	+16,575
17,200	880	1,240	−360	840	480	+360	8.6	4.5	+4.1	23,702	7,088	+16,614
17,400	880	1,160	−280	720	440	+280	7.8	3.9	+3.9	18,424	5,632	+12,792
17.600	840	1,120	−280	600	480	+120	6.9	3.5	+3.4	13,579	5,512	+ 8,067
17,800	760	1,200	−440	560	480	+ 80	6.6	2.6	+4.0	12,124	4,095	+ 8,029
18,000	760	1,240	−480	520	520	00	6.3	1.9	+4.4	10,729	3,236	+ 7,493
18,200	720	1,320	−600	520	480	+ 40	6.2	1.8	+4.4	10,559	2,835	+ 7,724
18,400	720	1,400	−680	520	480	+ 40	5.9	2.3	+3.6	10,048	3,622	+ 6,426
18,600	720	1,440	−720	520	440	+ 80	5.5	2.7	+2.8	9,367	3,899	+ 5,468
18,800	720	1,440	−720	560	400	+160	5.0	3.0	+2.0	9,185	3,939	+ 5,246
19,000	720	1,440	−720	560	440	+120	4.5	3.5	+1.0	8,266	5,054	+ 3,212
19,200	800	1,360	−560	400	480	− 80	3.5	3.5	+0.0	4,596	5,512	− 916

TABLE II.—*Joe Flogger Shoal, comparative dimensions*—Continued.

Distance on base.	Location.		Difference.	Width.		Difference.	Mean elevation.		Difference.	Area of cross-section.		Difference.
	1842.	1883.		1842.	1883.		1842.	1883.		1842.	1843.	
Meters.	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Sq. feet.*
19,400	840	1,360	—520	320	480	—160	2.6	3.7	—1.1	2,730	5,828	—3,098
19,600	840	1,360	—520	400	480	—80	2.8	4.8	—2.0	3,676	7,560	—3,884
19,800	880	1,360	—480	520	520	00	3.0	6.7	—3.7	5,109	11,410	—6,301
20,000	880	1,320	—440	520	520	00	2.9	7.1	—4.2	4,939	12,091	—7,152
20,200	920	1,320	—400	480	560	—80	2.6	6.8	—4.2	4,095	12,492	—8,397
20,400	920	1,280	—360	480	560	—80	2.5	6.5	—4.0	3,938	11,940	—8,002
20,600	1,000	1,280	—280	480	560	—80	2.4	6.5	—4.1	3,780	11,940	—8,160
20,800	1,040	1,280	—240	560	560	00	2.6	6.7	—4.1	4,776	12,308	—7,532
21,000	1,080	1,280	—200	560	560	00	3.1	7.1	—4.1	5,695	13,043	—7,348
21,200	1,120	1,280	160	560	600	—40	3.8	7.4	—3.6	6,980	14,563	—7,583
21,400	1,120	1,280	160	560	640	—80	4.7	7.3	—2.6	8,634	15,330	—6,696
21,600	1,120	1,240	—120	560	600	—40	5.6	6.7	—1.1	10,287	13,186	—2,899
21,800	1,120	1,280	—160	560	600	—40	6.2	6.3	—0.1	11,389	12,398	—1,009
22,000	1,120	1,240	—120	600	600	00	6.4	6.2	+0.2	12,595	12,202	+ 393
22,200	1,120	1,240	—120	680	640	+40	6.1	6.9	—0.8	13,609	14,490	—881
22,400	1,120	1,160	—140	720	600	+120	6.0	7.6	—1.6	14,172	14,957	—785
22,600	1,120	1,080	+40	760	600	+160	6.0	7.7	—1.7	14,958	15,154	—196
22,800	1,080	1,080	00	800	600	+200	6.5	7.6	—1.1	17,062	14,957	+2,105
23,000	1,040	1,080	40	800	600	+200	7.1	6.9	+0.2	18,638	13,579	+5,059
23,200	1,000	1,040	—40	840	560	+280	7.6	6.5	+1.1	20,946	11,940	+9,006
23,400	1,000	1,040	—40	880	600	+280	7.8	6.5	+1.3	23,519	12,792	+10,727
23,600	960	1,000	—40	920	560	+360	7.9	6.3	+1.6	23,842	11,573	+12,269
23,800	920	1,000	—80	960	600	+360	8.0	5.5	+2.5	25,200	10,824	+14,376
24,000	920	960	—40	920	600	+320	8.1	5.0	+3.1	24,446	9,840	+14,606
24,200	920	1,000	—80	880	600	+280	8.1	5.0	+3.1	23,385	9,840	+13,545
24,400	920	1,000	—80	880	640	+240	7.9	5.1	+2.8	22,807	10,710	+12,097
24,600	960	1,000	—40	840	720	+120	7.9	4.7	+3.2	21,772	11,101	+10,671
24,800	960	1,000	—40	800	840	—40	8.0	3.9	+4.1	21,000	10,748	+10,252
25,000	960	1,040	—80	760	1,000	—240	8.1	3.2	+4.9	20,193	10,499	+9,694
25,200	960	1,080	—120	760	960	—200	7.4	2.7	+4.7	18,448	8,505	+9,943
25,400	960	1,160	—290	760	920	—160	6.2	2.4	+3.8	15,457	7,243	+8,214
25,600	960	1,160	—200	800	800	00	5.4	2.0	+3.4	14,175	5,250	+8,925
25,800	960	1,200	—240	760	600	+160	3.9	1.9	+2.0	9,723	3,739	+5,984
26,000	960	1,120	—140	680	0	+680	2.6	.0	+2.6	5,801	0	+5,801
26,200	1,000			560			1.6			2,939		
26,400	1,040			320			0.9			945		
26,600	1,120			0			0.0					
*Mean				786	629	+157	6.3	5.6	0.7	16,633	11,900	+4,733
Mean				741			5.9			15,448	11,900	

*The foregoing is from a plotting on profile paper prepared from the original sheets by W. B. Fairfield, computer, June, 1886.

NOTE.—The "location" in the foregoing table is that of the axis of the shoal; the "width" is that of the base of the shoal at plane 18 feet below low water of spring tides. The "mean elevation" is the mean ordinate of the profile of the cross-section, the base being 18 feet below low water of spring tides. All corrections for projections and planes of reference have been introduced. Two sets of means are given, the first set being limited to present length of shoal.—H. M.

TABLE III.—*Lower Channel (Blake's), near Joe Flogger Shoal.*

THALWEG.

Distance on base.	Channel depth.		Difference.	Distance on base.	Channel depth.		Difference.
	1841.	1883.			1841.	1883.	
Meters.	*Feet.*	*Feet.*	*Feet.*	*Meters.*	*Feet.*	*Feet.*	*Feet.*
0	29.0	....	....	8,600	27.5	28.5	—1.0
200	27.0	....	....	8,800	27.0	27.0	0.0
400	27.0	....	....	9,000	26.0	25.5	+0.5
600	28.0	....	....	9,200	27.5	25.5	+2.0
800	23.0	....	....	9,400	25.5	24.5	+1.0
1,000	23.0	....	....	9,600	25.0	20.0	+5.0
1,200	25.5	....	....	9,800	25.0	23.5	+1.5
1,400	28.5	....	....	10,000	23.5	22.5	+1.0
1,600	26.0	....	....	10,200	22.0	24.5	—2.5
1,800	26.0	23.5	+2.5	10,400	22.5	24.5	—2.0
2,000	26.5	25.0	+1.5	10,600	24.0	26.5	—2.5
2,200	27.5	26.5	+1.0	10,800	24.0	26.5	—2.5
2,400	28.0	26.5	+1.5	11,000	25.5	25.5	0.0
2,600	27.0	26.5	+0.5	11,200	25.0	25.0	0.0
2,800	27.0	26.5	+0.5	11,400	23.5	26.0	—2.5
3,000	27.0	27.5	—0.5	11,600	25.0	23.5	+1.5
3,200	26.5	27.5	—1.0	11,800	26.5	28.5	—2.0
3,400	26.0	27.0	—1.0	12,000	28.0	28.5	—0.5
3,600	27.0	26.5	+0.5	12,200	28.0	29.0	—1.0
3,800	29.0	28.0	+1.0	12,400	29.0	28.0	+1.0
4,000	28.0	28.5	—0.5	12,600	28.0	27.0	+1.0
4,200	26.0	28.5	—2.5	12,800	28.0	29.0	—1.0
4,400	25.0	29.5	—4.5	13,000	30.0	30.0	0.0
4,600	26.0	28.0	—2.0	13,200	28.0	31.0	—3.0
4,800	26.5	26.5	0.0	13,400	26.0	31.0	5.0
5,000	27.0	26.5	+0.5	13,600	24.5	30.5	—6.0
5,200	26.0	26.5	—0.5	13,800	23.0	30.5	—7.5
5,400	26.0	26.5	—0.5	14,000	26.0	30.0	—4.0
5,600	26.0	26.0	0.0	14,200	25.5	29.5	—4.0
5,800	26.0	25.5	+0.5	14,400	24.5	28.0	—3.5
6,000	26.0	25.5	+0.5	14,600	24.0	28.5	—4.5
6,200	26.0	25.5	+0.5	14,800	24.0	28.0	—4.0
6,400	26.0	25.5	+0.5	15,000	26.0	27.5	—1.5
6,600	26.0	25.5	+0.5	15,200	25.0	27.5	—2.5
6,800	26.0	25.5	+0.5	15,400	24.0	28.0	—4.0
7,000	25.0	26.0	—1.0	15,600	24.0	29.0	—5.0
7,200	24.5	27.5	—3.0	15,800	25.0	30.0	—5.0
7,400	26.0	26.5	—0.5	16,000	24.5	30.5	—6.0
7,600	21.5	26.5	—5.0	16,200	32.0	31.0	+1.0
7,800	28.0	27.5	+0.5	16,400	37.0	31.5	+5.5
8,000	28.0	28.0	0.0	16,600	24.0	29.5	—5.5
8,200	30.0	28.5	+1.5	16,800	28.0	33.0	—5.0
8,400	29.5	28.5	+1.0	17,000	30.0	30.5	—0.5

TABLE III.— *Lower Channel (Blake's), near Joe Flogger Shoal*—Continued.

THALWEG—Continued.

Distance on base.	Channel depth. 1841.	Channel depth. 1883.	Difference.	Distance on base.	Channel depth. 1841.	Channel depth. 1883.	Difference.
Meters.	*Feet.*	*Feet.*	*Feet.*	*Meters.*	*Feet.*	*Feet.*	*Feet.*
17,200	37.0	33.5	+3.5	22,600	43.5	51.0	—7.5
17,400	39.0	34.5	+4.5	22,800	45.5	53.0	—7.5
17,600	40.0	35.0	+5.0	23,000	47.0	53.5	—6.5
17,800	38.5	35.5	+3.0	23,200	48.0	53.5	—5.5
18,000	37.0	36.0	+1.0	23,400	48.0	53.5	—5.5
18,200	33.0	36.5	—3.5	23,600	49.0	54.5	—5.5
18,400	34.0	36.5	—2.5	23,800	50.5	58.0	—7.5
18,600	34.5	36.5	—2.0	24,000	51.0	57.0	—6.0
18,800	36.0	38.0	—2.0	24,200	49.0	53.5	—4.5
19,000	37.0	42.0	—5.0	24,400	47.5	49.0	—1.5
19,200	37.5	44.5	—7.0	24,600	45.5	52.5	—7.0
19,400	38.0	43.0	—5.0	24,800	46.5	54.5	—8.0
19,600	38.0	42.0	—4.0	25,000	50.5	47.5	+3.0
19,800	36.0	41.5	—5.5	25,200	49.5	50.0	—0.5
20,000	36.0	42.0	—6.0	25,400	48.0	52.0	—4.0
20,200	38.0	42.5	—4.5	25,600	47.0	53.0	—6.0
20,400	38.0	41.5	—3.5	25,800	46.0	51.5	—5.5
20,600	38.0	44.5	—6.5	26,000	45.5	50.5	—5.0
20,800	38.0	44.5	—6.5	26,200	46.0	47.5	—1.5
21,000	39.0	44.5	—5.5	26,400	45.0	--------	----------
21,200	39.0	45.5	—6.5				
21,400	40.0	45.5	—5.5	Mean	32.2	34.3	—2.1
21,600	41.0	45.0	—4.0				
21,800	43.0	44.5	—1.5	Mean of first half from 0 to 13,000	26.3	26.5	—0.2
22,000	42.0	48.0	—6.0				
22,200	40.0	48.0	—8.0	Mean second half from 13,000 to 26,400	37.3	41.1	—3.8
22,400	41.5	48.5	—7.0				

TABLE IV.—*Upper or Main Channel near Joe Flogger Shoal.*

Distance on base.	Channel depth. 1841.	Channel depth. 1883.	Difference.	Distance on base.	Channel depth. 1841.	Channel depth. 1883.	Difference.
Meters.	*Feet.*	*Feet.*	*Feet.*	*Meters.*	*Feet.*	*Feet.*	*Feet.*
0	41.0	-------	---------	9,000	38.5	42.0	− 3.5
200	41.0	44.5	− 3.5	9,200	39.5	43.0	− 3.5
400	41.5	45.0	− 3.5	9,400	40.0	43.5	− 3.5
600	42.5	45.5	− 3.0	9,600	41.0	44.0	− 3.0
800	44.5	46.5	− 2.0	9,800	41.0	44.5	− 3.5
1,000	44.0	47.5	− 3.5	10,000	39.0	44.5	− 5.5
1,200	43.0	47.5	− 4.5	10,200	40.5	46.0	− 5.5
1,400	42.5	47.0	− 4.5	10,400	43.0	46.5	− 3.5
1,600	42.5	46.5	− 4.0	10,600	43.0	45.5	− 2.5
1,800	45.5	46.5	− 1.0	10,800	43.5	44.5	− 1.0
2,000	43.5	47.5	− 4.0	11,000	44.5	45.5	− 1.0
2,200	43.0	47.0	− 4.0	11,200	45.0	44.5	+ 0.5
2,400	42.0	47.0	− 5.0	11,400	44.5	44.5	0.0
2,600	41.0	47.5	− 6.5	11,600	44.0	44.0	0.0
2,800	40.5	47.0	− 6.5	11,800	43.5	43.0	+ 0.5
3,000	41.5	46.5	− 5.0	12,000	42.5	41.0	+ 1.5
3,200	41.0	45.5	− 4.5	12,200	42.0	39.5	+ 2.5
3,400	43.0	47.0	− 4.0	12,400	41.0	39.5	+ 1.5
3,600	46.5	47.5	− 1.0	12,600	39.5	38.5	+ 1.0
3,800	45.0	47.5	− 2.5	12,800	38.0	39.5	− 1.5
4,000	44.0	46.5	− 2.5	13,000	36.5	41.0	− 4.5
4,200	43.5	49.5	− 6.0	13,200	42.0	41.0	+ 1.0
4,400	42.0	49.5	− 7.5	13,400	39.0	41.5	− 2.5
4,600	41.0	51.5	−10.5	13,600	39.5	44.0	− 4.5
4,800	41.5	53.5	−12.0	13,800	41.0	45.5	− 4.5
5,000	44.0	53.5	− 9.5	14,000	40.0	46.5	− 6.5
5,200	46.5	50.5	− 4.0	14,200	40.5	46.5	− 6.0
5,400	43.0	50.5	− 7.5	14,400	44.0	47.5	− 3.5
5,600	44.0	49.5	− 5.5	14,600	34.0	36.0	− 2.0
5,800	47.5	49.0	− 1.5	14,800	32.5	44.0	−11.5
6,000	44.5	48.5	− 4.0	15,000	41.5	50.0	− 8.5
6,200	42.5	47.0	− 4.5	15,200	35.5	50.5	−15.0
6,400	43.0	44.0	− 1.0	15,400	35.0	49.5	− 14.5
6,600	44.0	46.5	− 2.5	15,600	40.0	48.5	− 8.5
6,800	45.0	45.0	0.0	15,800	44.5	47.5	− 3.0
7,000	44.5	44.0	+ 0.5	16,000	41.0	46.5	− 5.5
7,200	43.5	43.5	0.0	16,200	38.0	45.5	− 7.5
7,400	42.0	42.0	0.0	16,400	39.5	44.0	− 4.5
7,600	40.0	41.0	− 1.0	16,600	41.0	43.5	− 2.5
7,800	39.0	40.5	− 1.5	16,800	42.0	46.0	− 4.0
8,000	39.0	39.5	− 0.5	17,000	43.5	44.0	− 0.5
8,200	39.0	39.5	− 0.5	17,200	45.0	42.0	+ 3.0
8,400	39.5	39.5	0.0	17,400	45.5	41.5	+ 4.0
8,600	40.0	39.5	+ 0.5	17,600	44.0	43.0	+ 1.0
8,800	39.5	40.0	− 0.5	17,800	44.0	43.5	+ 0.5

TABLE IV.—*Upper or Main Channel near Joe Flogger Shoal*—Continued.

Distance on base.	Channel depth.		Difference.	Distance on base.	Channel depth.		Difference.
	1841.	1883.			1841.	1883.	
Meters.	*Feet.*	*Feet.*	*Feet.*	*Meters.*	*Feet.*	*Feet.*	*Feet.*
18,000	44.5	43.5	+1.0	22,600	45.5	50.5	−5.0
18,200	43.0	43.0	0.0	22,800	46.0	51.0	−5.0
18,400	41.0	43.0	−2.0	23,000	46.0	50.5	−4.5
18,600	40.5	46.0	−5.5	23,200	46.5	48.5	−2.0
18,800	42.0	42.0	0.0	23,400	50.0	46.0	+4.0
19,000	44.0	45.5	−1.5	23,600	50.0	45.5	+4.5
19,200	44.0	47.0	−3.0	23,800	50.0	47.5	+2.5
19,400	45.0	48.0	−3.0	24,000	48.5	46.5	+2.0
19,600	46.0	48.5	−2.5	24,200	46.0	47.5	−1.5
19,800	46.5	49.5	−3.0	24,400	44.0	46.0	−2.0
20,000	47.0	50.5	−3.5	24,600	42.5	45.5	−3.0
20,200	42.0	49.5	−7.5	24,800	41.0	45.5	−4.5
20,400	45.5	50.5	−5.0	25,000	40.0	45.5	−5.5
20,600	48.0	49.0	−1.0	25,200	39.0	45.0	−6.0
20,800	46.0	48.0	−2.0	25,400	38.5	44.5	−6.0
21,000	45.0	49.5	−4.5	25,600	39.5	44.5	−5.0
21,200	45.0	51.5	−6.5	25,800	40.0	45.0	−5.0
21,400	45.0	51.5	−6.5	26,000	40.0	44.5	−4.5
21,600	48.0	51.0	−3.0	26,200	39.5	48.0	−8.5
21,800	46.0	50.5	−4.5				
22,000	45.0	49.0	−4.0				
22,200	45.0	45.5	−0.5	Mean	42.6	45.8	−3.2
22,400	45.0	50.5	−5.5				

APPENDIX No. 11.—1886.

A REPORT OF GULF STREAM EXPLORATIONS—OBSERVATIONS OF CURRENTS, 1886.

By Lieut. J. E. PILLSBURY, U. S. N., Assistant.

U. S. COAST AND GEODETIC SURVEY STEAMER BLAKE,
August 20, 1886.

DEAR SIR: I have to make the following report of the season's work of the hydrographic party under my command, investigating the currents of the Gulf Stream, in obedience to your general instructions, dated January 9, 1886.

The Blake left Washington on the morning of February 16, having been delayed over a month after the party was ready to leave by ice in the Potomac River. Havana was visited early in the season to obtain authority to establish a tide-gauge in the vicinity of Cape San Antonio, Cuba, for the purpose of gaining some knowledge of the relation, if any, existing between the entrance of the tidal wave into the Gulf of Mexico and the variations in the velocity of the Gulf Stream at cross-section A.

The United States Consul-general, the Captain of the Port of Havana, and the Minister of Marine all advised against the proposed plan, although the permission to carry it out could be readily obtained. I therefore determined to establish it at Tortugas, and for that purpose visited the locality and placed the gauge near the fort at Garden Key.

Every opportunity was taken during the season to obtain the current observations, the only break of any length of time being about ten days, which time was required to go to New Orleans for bituminous coal, that at Key West, which it was proposed to purchase, having been destroyed in the great fire which devastated the city in the early part of April. When at anchor in the stream it was necessary to have, at all times, a good pressure of steam on the boilers, so that the anchor could be weighed, and the engines started at a moment's notice, and for this reason hard coal could not be used.

The weather in March and April was abnormally bad, strong northerly winds and heavy seas prevailing most of the time, and indeed, the whole season was entirely different from the year before. The mean maximum and minimum temperatures for the two years were:

Month	Mean maximum and minimum temperatures.				Temperature of surface water.	
	1885.		1886.		1885.	1886.
	Max.	Min.	Max.	Min.		
	°	°	°	°	°	°
April	80.2	78.0	77.8	74.3	79.2	76.9
May	86.6	83.8	83.7	80.7	80.7	80.5

The winter of 1885–'86 in the Bahamas and at Key West was said to have been more severe than ever before known, fish in vast numbers being killed or benumbed on the shoals. In 1885, during April and May, there was rarely a day on which rain did not fall, while in 1886 we scarcely had one shower during either month. These are but signs of different conditions of the elements in the two years. Without having the meteorological record of a number of years to which to refer, I think, from the local evidence, we may conclude that 1886 was abnormal and 1885 was nearly a normal year.

The Gulf Stream currents of the past season showed many erratic features, as if influenced by something which did not follow any regular law.

This season there were three current meters on board of the same pattern as those used last year.* The observations were taken in the same manner, except that one meter was used for the surface and another for the subsurface currents, but frequently interchanged. This increased the rapidity with which the data for any depth was obtained. The meters were allowed to register, for the surface one hour and for the others thirty minutes, except the first set after anchoring, when they were thirty minutes for the surface and twenty minutes for 15 and 30 fathoms, these being shortened so as to have a complete set at the start as soon as possible.

In the anchoring gear an accumulator of 13 feet was used, and a distance-line of steel-wire rope attached to the boom end, which was of sufficient length to allow the accumulator rubbers to compress about 5½ feet (which was about their limit of elasticity), the pressure being about 15,000 pounds. Any greater strain than this was taken by the distance-line, the boom at that time being at an angle of 30°. With any angle greater than this the topping-lift and distance-line would have to bear a less strain than there was on the anchoring wire, but with a less angle the strain on the former would be rapidly multiplied. Instead of a pulley at the masthead for the topping-lift, a pendulum 3½ feet long was substituted. The accumulator was shackled to the lower end of this, leading forward, and the after leg of the topping-lift leading aft. The variations in strain vibrated this pendulum slightly, but still practically made only a down thrust on the mast. This was used instead of the pulley, as last year, to obviate the danger of stranding the topping-lift by the continuous slight bending backward and forward over the pulley, due to the variation of the strain.

At the heel of the anchoring boom a ball and socket-joint was substituted for the goose-neck hinge, and although the currents this year were at times stronger than last, there were no signs of its giving way.

The pawl-bitt, which took the thrust of the boom, was strengthened by a long jack-screw thrusting forward, thus transferring a part of the strain on the bitt to the deck beams farther aft.

The system employed in anchoring, and the use of the rubber accumulator to support the boom end, enabled us to detect at once if the vessel dragged, and also to determine something of the relative strength of the currents. With a stronger subcurrent than on the surface, the vibrations of the anchoring wire would be great. The vibrations sometimes seemed to commence far below the surface, and increased from being just perceptible to very violent. If the anchor dragged but was clear, the boom jumped violently; but if it was foul, and dragging crown first over sand, the tremble was easily distinguished, and the cause assigned correctly.

In making a discussion of the most salient features in the observations obtained this season I shall also include those of last year, in order to show the agreement between the two. It is impossible, however, in so short a time to do more than give but a partial review, as the press of other duties prevents.

The study alone of the influence of the winds and barometer on the Gulf Stream, will require in itself a long time, and very much more than I can give to it. I hope, however, that some of the eminent gentlemen of America who have made tides and currents a life-long study, may be given the opportunity to solve the many problems I leave untouched, for which I believe in the observations obtained there will be found sufficient and trustworthy data.

At the instance of Prof. Henry Mitchell, I made an experiment for the purpose of confirming the observations of the current meter. A number of years ago he made some investigations in

* See Appendix No. 14, Report for 1885.

the Gulf Stream to ascertain the velocity of the subcurrents by floating two pairs of spheres, one pair with the lower sphere weighted and suspended at various distances below its mate, and the other pair floating in the upper strata. They always maintained the same velocity, from which he concluded that the current from surface to bottom was flowing with like speed. He suggested, therefore, that, while he did not doubt the direct evidence of my current meter, it would be well to try the experiment he did. The meter shows that on the east side of the stream (Station 5) the difference of the velocity at the surface and at 130 fathoms is rarely one-half knot, and the current at 65 is faster than at 15 or 30 fathoms. It shows also that on all stations there are times, and nearly every day, when the current at the surface is running less than at 15 fathoms, 30 fathoms, or even 65 fathoms.

In making my trial, therefore, I selected a time when the current meter indicated a very slight current at 130 fathoms. Two oil barrels were fastened together by a piece of steel wire (No. 16 gauge) 140 fathoms long. The lower barrel was weighted so that the upper one was about 3 inches out of water. The sea was perfectly smooth, and for the first half of the time there was no wind, and after that only a very gentle breeze.

These were put overboard, and alongside the surface barrel a pair of cans was dropped, the lower one being suspended 4 fathoms below the surface. Most of the officers on board declared that so great was the wake of the floating barrel, that its mate 140 fathoms down must be anchored in the bottom. The angle between Fowey Rocks Light-House and Cape Florida and the bearings were continually changing (we were about 8 miles distant from the former), but I took a sounding close alongside the barrel, and found 205 fathoms. The surface pair was in the mean time fast drifting out of sight. The means of fixing the relative positions of the two pairs was of course rather inaccurate for so short a drift, but the fact was demonstrated that the surface pair was going at about twice the speed of the other.

I shall take up the various portions of this report on the observations in the following order:

I. General characteristics of the Gulf Stream as developed by the observations.
II. Daily variation of the stream.
III. Monthly variation of the stream.
IV. Axis of the stream.
V. Effect of wind on the velocity of the stream and the position of its axis.
VI. Depth of the stream and velocity at different depths.
VII. General summary with rules for the guidance of navigators.

I. In my report of last year's observations in the same waters, I concluded that there was a daily variation of the stream, that there was a monthly variation, and that the axis of the stream was not situated at the point at which it was generally supposed. I have seen nothing in this year's observations which has caused me to reverse the conclusions of last year or to modify them, and I think I can give predictions on these points with a degree of exactness quite sufficient for the needs of the navigator.

With such a vast body of water, subject to so many influences, variations will always exist from causes far removed from its immediate vicinity, and for which no allowance can be made by the navigator, for want of knowledge of their existence. Prediction can be based upon the date and the declination, phase, and meridian passage of the moon, throwing out of consideration the possible weather in the Atlantic and Gulf of Mexico.

The regular variation of the stream consists of a daily change in velocity amounting at times to $2\frac{1}{2}$ knots. This difference in rate has taken place within three or four hours, as if a large wave traveled up the stream, its front face being steep and its rear less inclined. The change has been seen to be accompanied by a tide rip when the wind was favorable for its formation, and within five minutes the speed of the current advanced over one-half a knot. As a rule all variations are more excessive on the surface than at a lower depth, and on the western side greater than on the eastern.

When the current is running at its maximum, the surface is very much faster than any current below; but when at its minimum the speed at 15 fathoms, and sometimes at even lower depths, down to 65 fathoms, is faster than at the surface.

II. I append herewith several plates (Nos. 23 to 28) showing the observations taken in the Gulf Stream during 1885 as well as 1886. In order to indicate the variations to the eye more readily, I have contracted the ordinates representing days to about the same space as those representing knots, but for use in making calculations for mean curves all observations were represented on a scale five times as large as this. These plates also show the declination of the moon in a continuous curve, north declination being about the middle line and south declination below. Above the middle line is shown a curve which is the mean of all those below. This mean curve was made by taking the average of the readings for each depth at each hour on the curves on the lower half (or rather the similar ones on the large scale). The solid black lines are the actual means thus obtained. The dotted black lines are supposed curves, and will be explained further on.

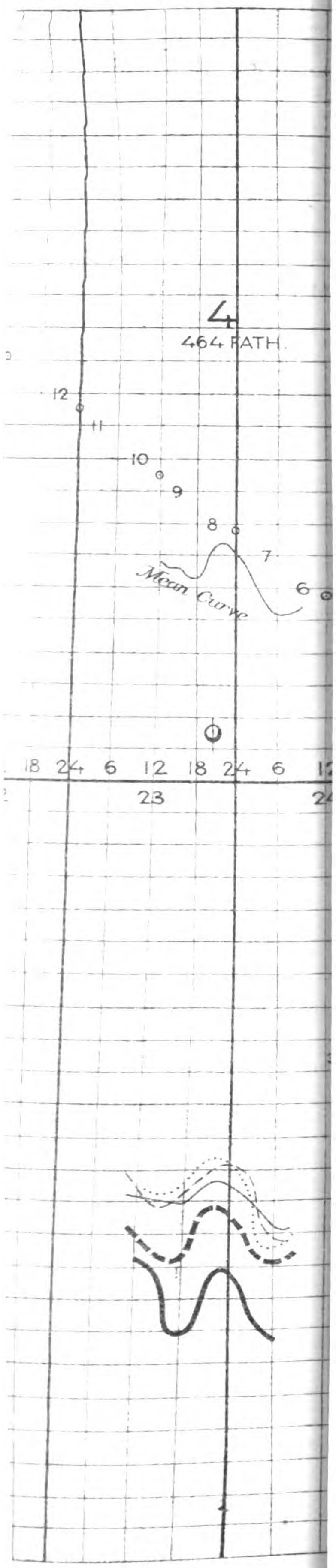
Referring to plates 23 and 24 (the observations of 1885), it will be noticed that the difference of time of the successive maximum velocities is about twenty-five hours, the average being $24^h\ 52^m$. The time of this maximum flow, when it comes before the upper transit of the moon, is indicated by the left-hand edge of the shaded space. The right-hand edge of the shaded space shows the time of the upper transit of the moon. Sometimes the maximum daily flow takes place after the upper transit of the moon. The time of this is represented by the parallelogram to the right of the shaded space. In the observations taken, however, there were but four times in the two seasons when the velocity was greater after the transit than it was before the preceding or succeeding transits. There is, however, on nearly every day an increase of velocity at this time followed by a decreased speed. The shaded space and the open parallelogram represent what may be called the establishment of the Gulf Stream at this point. The average of the former is $9^h\ 9^m$ before and the latter $3^h\ 36^m$ after the upper transit. This establishment is taken from the mean curve as found from the observations in the manner described, on the supposition that the mean flow of the stream truly represents the average flow of the surface current. This, however, may not be absolutely true, from the fact that observations on one station may have been taken at a time when the conditions effecting the variations were exerting their influence toward a maximum flow at, say, the surface, and at another time the reverse. It is thought, however, that the average of the mean curves does represent very nearly the average of the surface as to *time* of the fluctuations; near enough, certainly, for all practical purposes for the navigator. The variation in *velocity* in the surface current is very much greater than in any of the subcurrents, and consequently the mean does not represent this. The time of the establishment of the surface currents is found to be, by the observations taken, $9^h\ 07^m$, differing but two minutes from that obtained from average of the means.

In 1885 observations were taken at one anchorage (Station 1) as long as possible, in order to gain a knowledge of the law of variations. During the past year the endeavor has been made to vary the stations as much as possible to ascertain the relative strength at different points.

Referring again to plates 23 and 24, it will be noticed, particularly at No. 1 station (on the western side of the stream), that the mean curves, when the observations are continuous for more than twenty-four hours, are very regular, with a high maximum about 9^h before and its lower maximum about $3^h\ 30^m$ after the upper transit.

As stated before, the first maximum is greater than the second, except on four days, the most noticeable being on May 14, 1885. It has been thought that probably this variation to the rule should come when the declination of the moon changes its name, in the same manner as the tides at some places in the Gulf of Mexico miss one high tide at this time, when the lower maximum becomes the higher; but the variations in the Gulf Stream seem to follow some other law. The observations, I fear, are not sufficiently numerous to determine these questions with certainty, but from those we have it seems that the exception does not come at any fixed declination, but does coincide most singularly to the full and change of the moon.

In the observations in May, 1885, on No. 1 station, until the 13th day the position of the diurnal and semi-diurnal waves caused the first maximum velocity to be the lesser of the two. On May 13 they had about the same velocity, and on the following day the maximum velocity, which should have arrived about nine hours before the moon's transit, was altogether wanting, and the one arriving after the transit was very high. This was on the day of the new moon and the fourth day after the change of declination from south to north.



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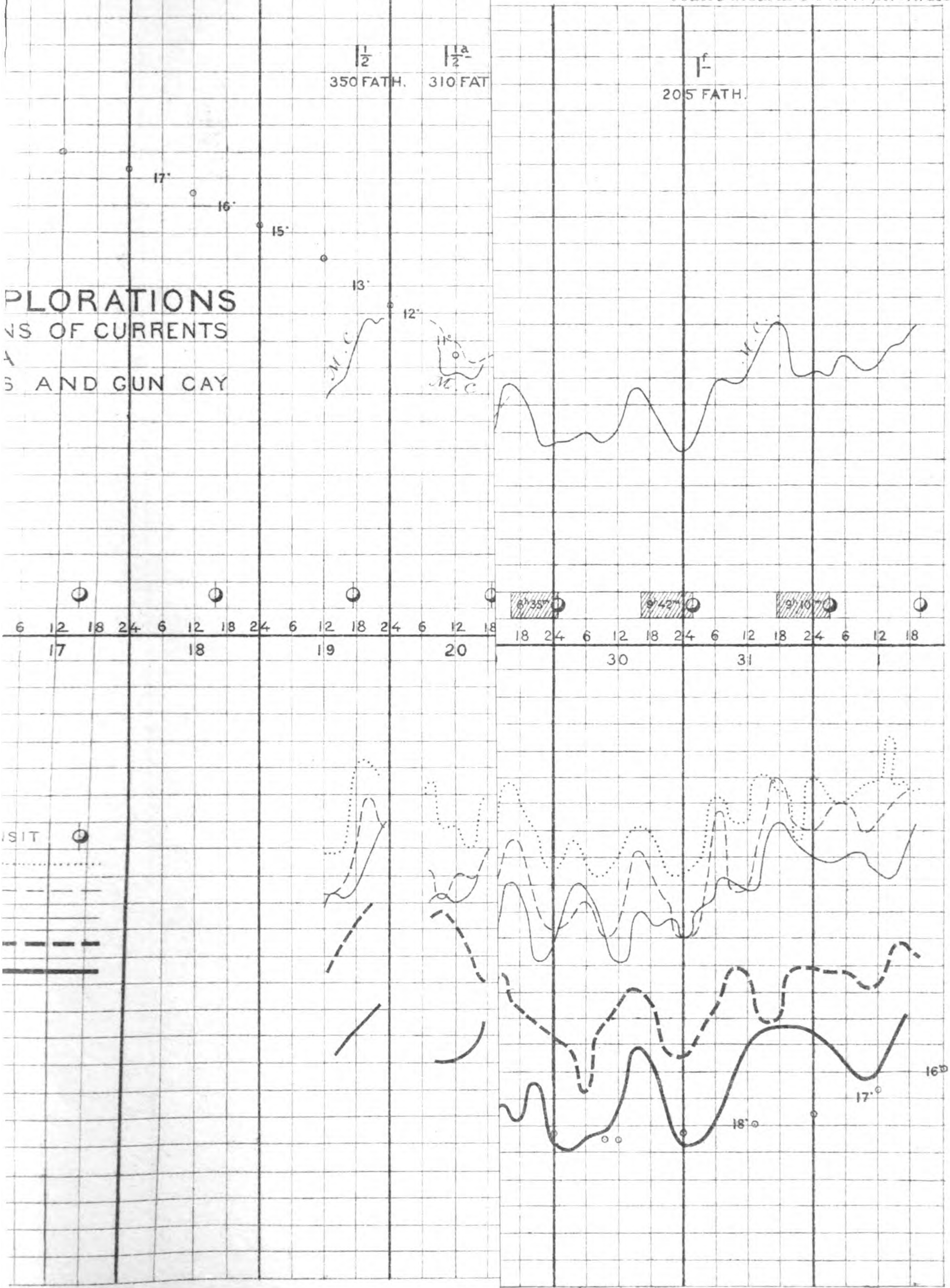
PLORATIONS
NS OF CURRENTS
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9h 10m
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31
1
18°
17°
16°

The next connected series of observations commenced on May 23, when we find the highest maximum was before the upper transit, but also *before* the lower maximum instead of after. The day previous to the next full moon, which was five days after the change of declination, we found the two high velocities about equal. Observations at No. 1 station were broken then in consequence of bad weather, but the record on No. 5 station on this day gave a very marked curve, descending more abruptly than at any other time at this place, and the highest point nine hours before the transit. This was seemingly as if the second maximum (the one following the previous transit) had been missed.

On May 1 and 2, 1886, bad weather prevented the observations just at the time when most important, but the ending of position 1^l and the beginning of No. 1^m (plate 26) indicated that the velocities before and after the transit were about equal. This was thirty-six hours after the change in declination, and the new moon followed about twenty-four hours later.

The day before the next full moon on Station 2 the maximum velocities were about equal on the third day after the change of declination, and on the day of the full, on Station $1\frac{1}{2}^b$, the maximum before the transit is wanting. It seems possible, therefore, from the few observations we have, that the change of form of this curve of currents takes place on the day of full and change of the moon, that at the time of new moon the highest maximum is omitted and the lower one increased, but only for the day, the next maximum arriving at its proper time. The shape of the curve then changes, the smaller wave going on the other side of the larger. I only draw your attention to this coincidence as a possible solution of this variation in the stream, but at the same time there are some reasons for the supposition that the change in the form of the curve follows the declination.

In order to show the agreement between the isolated observations taken on Station 1 in 1885, I have inserted between them some supposed curves in dotted black lines. The supposed curves, however, are actual ones taken from the observations at some other time in the month, and either inserted direct or reversed, according as the daily means were increasing or decreasing. It will be noticed that the dotted curves seem to fit perfectly, and in passing those of other stations the maximum and minimum velocities coincide with great exactness. Commencing with May 3, 1885, to connect a few hours' observations taken on Station 1^a with those of No. 1^b, the supposed curve was taken from 1^e and 1^f and reversed. On May 10 the supposed and actual maxima agree in time although not in velocity, on the 9th and 8th the supposed is nearer the average in point of time than the observed. On May 5 no observation was taken at the time of greatest velocity, but the curves on No. 5^a and 4^a point to a maximum at the same time that the supposed curve of No. 1 station. The latter on May 3 arrives at a point which is higher than the actual observations on Station 1^a, but coinciding with the proper "establishment" of 9 hours before the upper transit of the moon. Between 1^c, 1^d, and 1^e stations a supposed curve has been inserted, using 1^f for the purpose. The agreement between it and the actual observations is very close, as will be seen. So on May 28, the curve connecting No. 1^e and 1^f in passing the curve of Station 5^b.

The observations of March and April of this year, while they are so few and for only short lengths of time, nevertheless show an agreement with the others in the time of the maximum flow, and are valuable for that purpose.

The variations in the current are much greater on the west side of the stream than on the east, the averages of all the whole days on each station being as follows:

Stations	1	1½	2	3	4	5
Variations (knots)	1.17	1.32	1.52	0.5	0.45	0.52

That is, on No. 1 station the mean variation of the surface current in twenty-five days' observations was 1.17 knots.

III. In addition to the daily variation there is a decided change during the month. The surface observations taken at No. 1 station have been averaged for each day and plotted on plate 27, with the velocity as the ordinate and the mean declination of the moon for the day as the abscissa. The solid line is for observations taken in 1885 and the dotted line 1886. The former

is most complete for the reason, as previously stated, that observations were made continuous for as long a period as possible, while during the latter year the position of the vessel was shifted frequently.

The average of the mean curves has also been plotted in the same way and found to agree with the average of the surface in form, but, of course, with a lower velocity.

It will be seen that in May, 1885, in which month most of the observations were taken, the curve takes an upward turn just before the greatest southern declination, and, reaching its maximum a day or two after, drops to a speed of about 2½ knots, which it maintains as the declination changes from south to north.

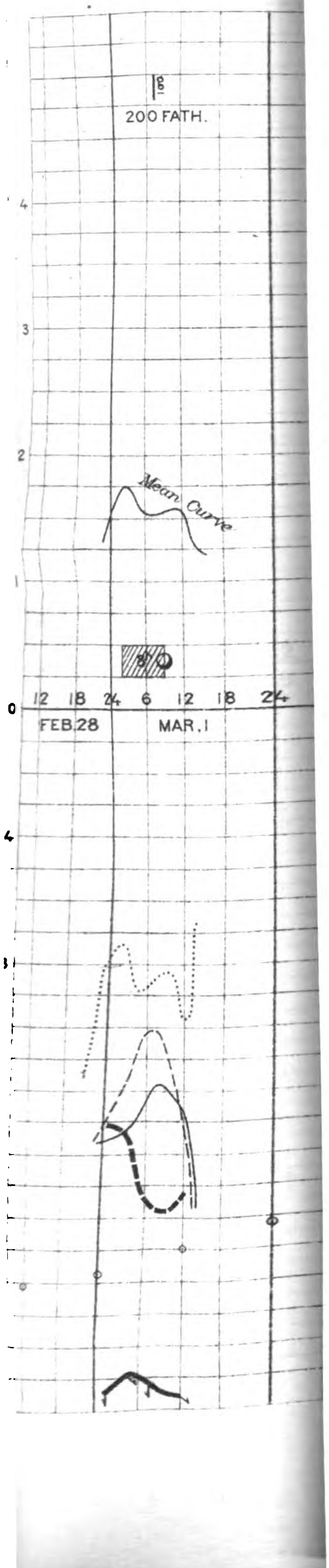
In 1886 the observations available (from their continuity) for this purpose show the same style of curve, with northern declination, but very much lower than the previous year in point of speed; but this occurred just at the time of the abnormal condition of weather in the early part of May. The curve of 1886, it is possible, may be normal, but it seems as if the portion above 8° north declination should be revolved upward, pivoting on the point of the curve representing the current at May 29. Confirming this view (that the curve is not normal), attention is drawn to the fact that on the previous year, on May 14, the current at the same station was 2½ knots, with about 14° north declination, which agreed within less than two-tenths of a knot of the speed, with the same southern declination, and that the former indicated by its form only a tendency to fall a trifle, in the same way that in the latter it was found to fall before the great rise, as the moon approached its greatest declination.

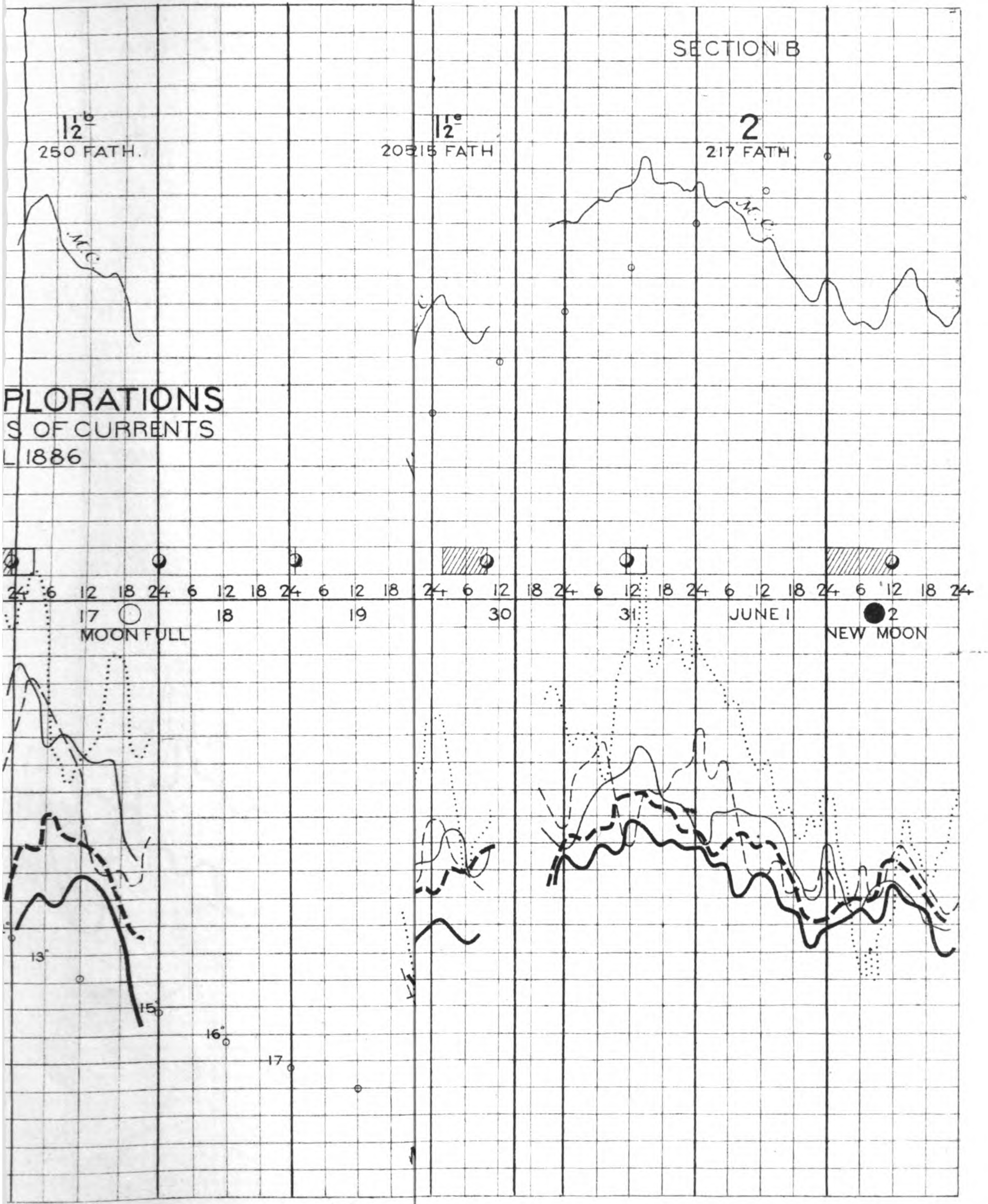
IV. The position of the axis of the Gulf Stream, or the point at which the flow of the stream is strongest on the surface, is a matter of great importance to the navigator, and during this season I have endeavored to arrange the observations so that the question could be settled. I suppose that this term "axis" should be considered to mean the point at which the greatest volume of water passes a given point in a given time, but as this is of no value to mariners, and as they do and will use the term most, I think it best to apply the name to the point of maximum surface flow, and for the other, to use the term "axis of volume." By last year's record I concluded that the axis was not at the position supposed by Professor Bache, but seemed to be on the west side instead of east of the mid stream. I at last determined that it was somewhere between Stations 1 and 2, the first about 8 and the other 15 miles from Fowey Rocks Light-House. I therefore occupied a station about midway between them, which I believe to be very near the position of greatest surface velocity, or the axis. In changing stations to or from No. 1½ (the station on the axis) as quickly as possible, it has invariably been found to have a greater velocity than the one with which it is compared, although the average of its twenty-four hours' observations may in some instances have been less than the others, in consequence of a rapid decline in velocity of the whole stream. I think in this case (as, for example, Stations 1 and 1½^c, May 21, 22, 23, of 1886), had I remained at Station 1^c, the curve of its surface current would have been at least half a knot below that at No. 1½^c. Station 1^c was just after the moon's greatest southern declination, when the current should have been running the strongest; No. 1½^c was at the time when the decline in speed should have been abrupt, and, besides this, something abnormal caused the maximum, both before and after the moon's transit of May 23, to be omitted. Upon ceasing observations at No. 1^c, at 9^h 15^m p. m. on May 22, the speed of the surface current was 2.78 knots. Two hours later, at No. 1½, it was 3.58 knots, and after a slight increase it rapidly decreased. The mean surface current at the various stations is shown in the following table, together with the number of hours used in obtaining the average and the distance from Fowey Rocks:

Station	1	1½	2	3	4	5
Distance from Fowey Rocks (miles)	8	11½	15	22	29	36
Hours	555	130	92	58	38	55
Velocity (knots)	2.569	3.6	3.18	2.843	2.376	1.785

Captains of the American coasting steamers navigating the Straits of Florida, have found by experience approximately where the maximum flow is, as they usually pass Fowey Rocks from 7

No. 25




SECTION B
$1\frac{1}{2}$b
250 FATH.
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M.C.
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17

to 11 miles distant. While the velocity of the current at 7 miles distant may be and is at times great, it is by no means so sure as at 11 miles off shore.

At No. 1[a] station, on May 5, 6, 1886, the current was remarkably slow, at times running as little as three-tenths of a knot per hour. At 8 a. m., with a surface current of 0.75 knot per hour, I changed to No. 2 and No. 3 stations successively, returning to No. 1 at 8 p. m. At the latter I found that the surface current had increased to 1.85 knots, but at No. 2 station I found the current to be from 3.2 knots to 3.7 knots and at No. 3 to vary from 2.4 to 2.7 knots.

I believe, therefore, the axis of the Gulf Stream at this cross-section is situated at No. 1½ station, about 11½ miles distant from Fowey Rocks. The fact that it is on the edge of the bank, where the water rapidly deepens from 200 to 400 fathoms, may be of value in drawing inferences as to the axis at other points of the stream, until we know from actual observations its exact locality.

V. The effect of wind on the Gulf Stream is, I think, believed to be most potent in changing the position of its axis, as well as in banking up the current or accelerating its velocity. In the observations I have taken in the stream, or outside its limits on the adjacent banks, I have found not the slightest evidence that the axis changes by the direct action of the wind to an extent discernible. Anchored on the edge of the adjacent banks with winds from certain directions, the clear blue water of the stream is blown towards the shore, but the current does not accompany it. On the Bahama side, the current is generally setting to the northward on the edge of the bank as far as 8 or 10 fathoms. On the Florida side, anchored in the line of the reefs, with a fresh SE. wind blowing directly on shore, there was no current. Anchored in the stream with winds from all directions, no change in the position of its axis was observed. At stations 5[e] and 4[b] I remained at anchor with quite strong winds from the northward and eastward. The currents at the surface and at 15 fathoms indicated a retardation, which I think was due to the wind. After leaving No. 4[b], I steamed across the stream, but could not anchor because of the roughness of the sea. The current found in crossing, however, was less than it should have been with normal conditions. On May 2, 3, 4, and 5 the wind was almost continuously from the eastward, varying in force from 1 to 5 (Beaufort scale). The current on the west side, at Station 1, at this time, had the local wind a power to change the position of the axis by its direct force, would have been strong; but, instead of that, it was so weak that for many hours we were actually riding to the wind, which at that time had but a force of 1 and 2. The cause of this phenomenal current, however, I believe to have been the wind.

At Station 1[l] on May 1 the currents were about normal in strength, but very irregular. On May 2 the upper strata dropped in velocity, while at 65 and 130 fathoms there was an increase. On May 5, at station 1[n], the average currents for the day were as follows:

Depths, fathoms	3⅓	15	30	65	130
Current, knots	0.56	0.75	0.97	1.06	0.65

The vertical curve of this day's currents and the mean curve of 1886, as well as the curve of both years, embracing 555 hours at No. 1 station, are shown on plate 27. On May 6 and 7 the upper strata increased in velocity with great rapidity; the lower strata decreasing.

Referring to the vertical curves mentioned above, it will be noticed that at Station 1[n], when the current was running slow at the surface, at 130 fathoms it was running at the same speed as the mean current for the two years, and faster than the mean of this year's observations; and that a continuation of the curves below 130 fathoms to the bottom, shows a large volume of water at the lower depths hastening north as if to re-establish the equilibrium.

It is said that during a norther, the Gulf Stream current along the Florida reefs, within 40 or 50 miles of Key West, sets very strong to the eastward, and at other times one cannot depend upon finding a current in either direction. I have no evidence from my own observations that such is the case, but I can readily see that in the confined waters of the Straits of Florida it might be true. A very strong norther would bank up the water on the Cuban side. In re-establishing the equilibrium the lower strata would set slightly toward the Florida shore, and, coming to the surface

when it strikes the shoaler water make a strong current setting to the eastward, where is usually an intermittent one. The same would not be true to such a marked extent with an easterly gale in the Straits of Bemini, because the northeast Providence Channel would give relief to a portion of the lower strata, in its endeavor to make to the eastward.

I think that the popular belief, that the axis of the Gulf Stream changes with the wind, is almost wholly due to the hitherto unknown daily variations. A Commander starting across the stream when it is running at its maximum would probably reach the opposite side in time to find a less current. On another passage, if he happened to cross with reverse conditions, the statement that the axis changes would probably be verified to the satisfaction of himself and his friends. My conclusions are, therefore, that any moderate wind does not alter the position of the maximum surface flow perceptibly; that a strong wind blowing with or against the current will accelerate or retard its velocity somewhat, and that in the confined portions of the stream between Florida and Cuba or the Bahamas a gale blowing at right angles to its axis may cause an increased velocity on the weather side; but of this last I have no positive evidence.

VI. The depth of the Gulf Stream current and the velocities at different depths: The vertical curves, representing the velocities at different depths, are shown on plates 27 and 28. They are constructed by taking the averages of the velocities at the various depths and plotting them with their proper co-ordinates.

The mean curves are constructed by giving the means at all depths on each of the stations equal values, instead of taking the average of all observations at each depth for the mean.

The surface current at every station had a higher velocity than at any lower depth. At times during the day, when the current was running at its lowest speed, the surface for a short interval became slower than at 15 fathoms, but the average for the twenty-four hours was almost invariably higher. At stations No. 1 and No. 1½ only, was I able to obtain observations near the bottom, and at the former the current was sometimes found setting to the southward. In 1885 this was not the case, except once or twice, and then with scarcely perceptible currents, but this year it has been noticed several times.

The mean curves of 1885 and 1886, it will be be noticed, are nearly together at 65 fathoms; above that depth there is a wide departure, the curves separating most at 30 fathoms, and below 65 fathoms there is another departure.

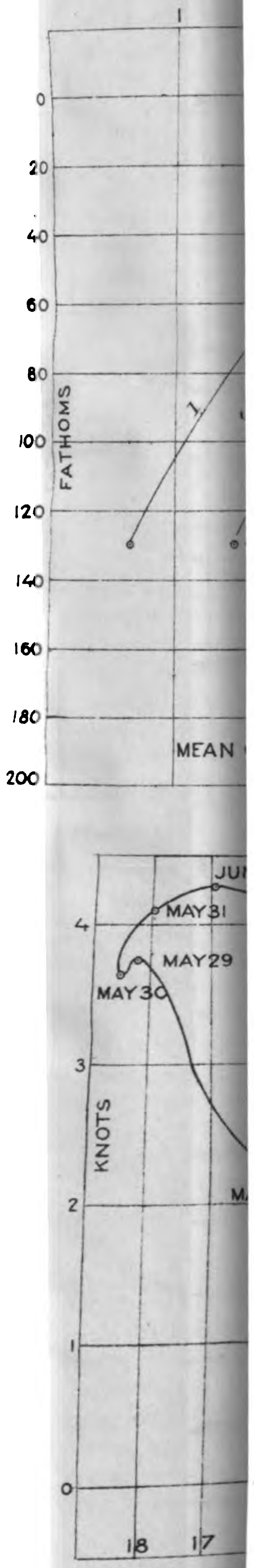
It seems from the vertical curves that at the bottom there is, at times, a current setting to the southward in all parts of the stream, except on the extreme eastern side. The vertical curves of all stations are plotted on plate 28, together with the curve of the bottom at cross-section A. The zero line of each vertical curve is shown at its proper distance from the shore on either side of the stream; but each curve is revolved around its zero to a position at right angles to the direction of the current.

Observations were taken for practical purposes only as far as 130 fathoms, the data taken below that depth not being sufficient to combine with advantage.

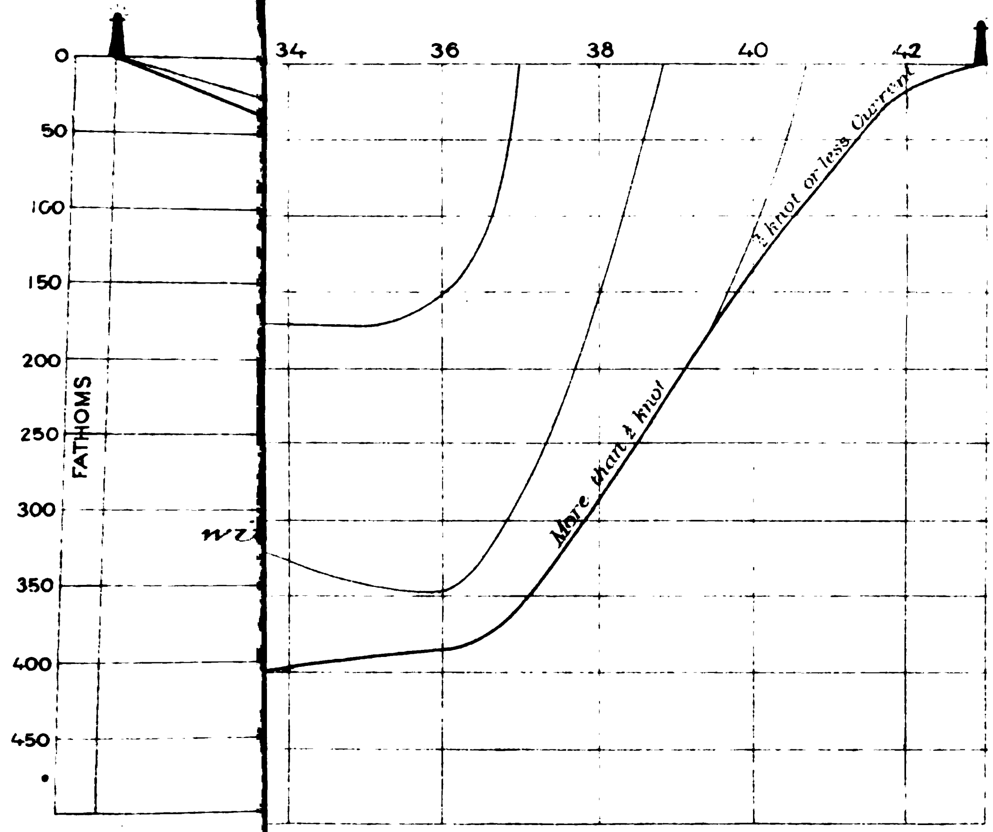
In order to give some idea of the strength of the currents below 130 fathoms, the curves have been continued to zero velocity. These curves, it will be remembered, are found from the average of all observations at each depth at each station. The curve at No. 1 and No. 1½ stations, situated on the slope, reach zero velocity about 25 fathoms from the bottom. Nos. 2 and 3 stations, it will be seen, arrive at zero at almost the same depths, and No. 5 station continued, seems to possess a current which reaches to the bottom.

The observations taken on this station (No. 5) during this year were in March and April and under exceptionably unfavorable weather. Attention has been drawn to one of these under the heading of the "Effect of wind." A slight error would affect the velocity at the bottom considerably, and it is possible that actually there is a less current than shown. The question as to whether the lower strata of water is motionless, or whether it has a movement north or south, my observations do not show absolutely, except on No. 1 station, where at 130 fathoms a southerly current was found at times. The form and position of this curve changes continually; sometimes, as on Station 1', with a considerable velocity at the bottom, and again, as on 1°, with a most decided southerly set at 130 fathoms. I believe that at all the stations the current to the northward may at times reach near the bottom, but at Nos. 2, 3, and 4 it rarely does.

No. 27

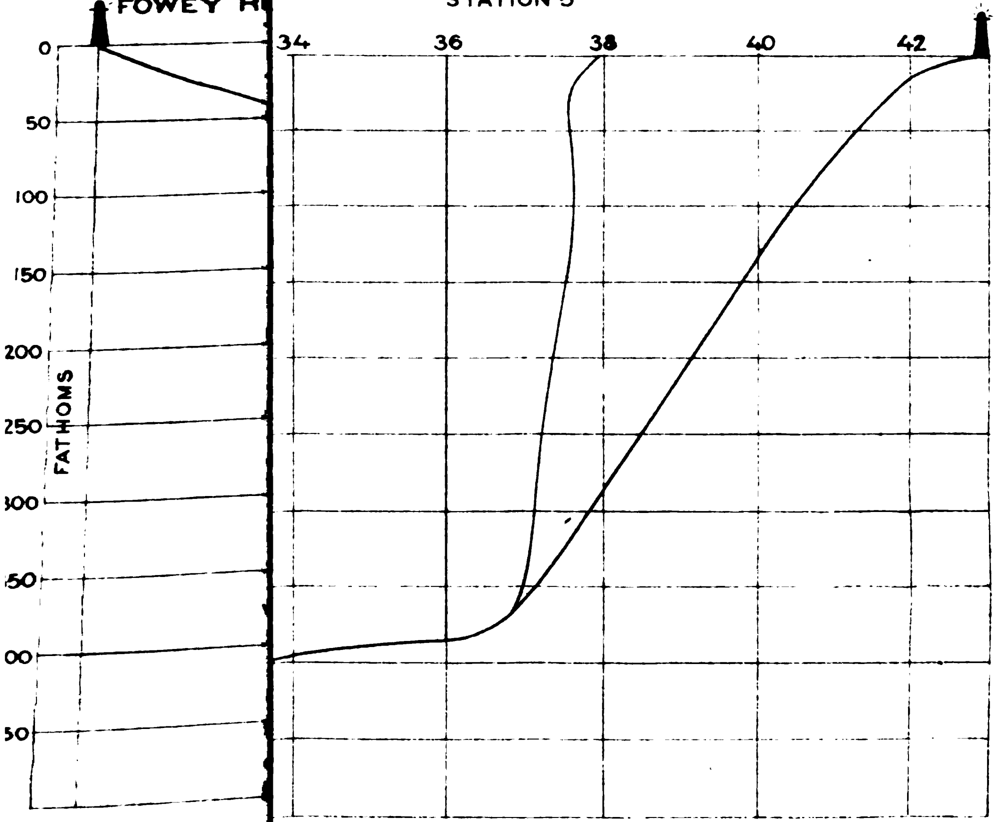


1
0
20
40
60
80
100
120
140
160
180
200
FATHOMS
MEAN
4
3
2
1
0
KNOTS
MAY 31
MAY 29
MAY 30
18
17



FOWEY R

STATION 5



At Nos. 1, 1½, 2, 4, and 5 stations dredgings have been made and more or less mud brought up, except at No. 5, where the dredge showed nothing but broken branch coral with a few small shells.

The curves of the various stations taken from west to east become more and more nearly vertical, and the point below the surface at which the current maintains about the same velocity extends farther down. At No. 1 station the swelling on the curve is but little, and is between 15 and 30 fathoms. On No. 5 it is at 65 fathoms.

On all stations the velocity at the surface is greater than at any depth below, but with one or two exceptions the record of the means indicates that a stratum of water below the surface is moving at a slightly greater speed than a stratum at some point between it and the surface, and also greater than the water below. It indicates that the volume of this stratum increases at the different stations from west to east. It is probable that on No. 5 station, where the current at 65 fathoms is greater than at 15 or 30 fathoms, if observations could be taken at 300 fathoms the current would be found to have decreased somewhat, so as to give greater inclination to the curve.

The variation in the curves near the surface will probably be found to follow very closely to the mean change of temperature in the Atlantic Ocean.

The curve of No. 1½ station near the surface seems to be abnormal, and probably a form approximating to that of No. 1 station would be nearer the true one.

The upper half of plate 28 shows the cross-section with curves indicating the limits of each stratum of water from zero to the maximum current, by increments of one half knot, as developed from the curves on the lower half of the sheet.

The space from each extreme station (Nos. 1 and 5) to the shore is divided proportionately, under the supposition that the decrease of the current shoreward is regular. I think, however, that this may not be true, for on the Florida side, close inshore, I believe a southerly current is sometimes found, but of this I have no positive evidence. As drawn on the plate, it serves to show approximately the average volume of each stratum.

VII. I have to submit the following summary of my conclusions, based upon the information obtained during the two seasons' observations. The examination of the Gulf Stream currents having been made in March, April, May, and June, the conclusions may be incorrect for other seasons of the year, although there are no good reasons for supposing that such is the case except, possibly, in the amount of the variations.

(1) Between Fowey Rocks, Florida, and Gun Cay, Bahamas, the current varies daily in velocity, at times as much as 2½ knots. The greatest velocity is generally about nine hours before the upper transit of the moon. The variations are most excessive on the west side of the straits and least on the east side.

(2) The average daily currents vary during the month, the strongest set coming a day or two after the greatest declination of the moon.

(3) The axis of the Gulf Stream, or the position of the strongest surface flow in passing this point, is 11½ miles east of Fowey Rocks Light-House. The strongest surface current found here was 5¼ knots per hour; the least, 1¾ knots; and the average, $3\frac{6}{10}$ knots. The average current at other places on either side of the axis is as follows:

	Knots.
Axis of the stream, 11½ miles from Fowey Rocks	3.6
3½ miles west, or 8 miles from Fowey Rocks	2.6
3½ miles east, or 15 miles from Fowey Rocks	3.2
10 miles east, or 22 miles from Fowey Rocks	2.8
17 miles east, or 29 miles from Fowey Rocks	2.4
24 miles east, or 36 miles from Fowey Rocks	1.8

(4) The wind probably retards or accelerates the velocity of the current. A NE. gale in the Atlantic will probably "bank up" the water of the stream, lowering its velocity materially, and afterwards the flow will, by the reaction, be greatly increased over the normal speed. There is no evidence of any change in position of the axis of the stream due to the wind.

(5) Two days' observations off Jupiter Light, Florida, indicate the same daily variation as was found off Fowey Rocks, and the axis of the stream at this section is probably about 17 miles east of the light.

This report would be incomplete without calling your attention to the admirable way in which the officers attached to the party have executed their share of the work. They have done it carefully and intelligently and have submitted to any amount of personal inconvenience or hardship in the cause.

The following is a list of the officers on board during the season: Ensigns T. D. Griffin, R. M. Hughes, A. G. Rogers, J. H. Hetherington, and F. R. Brainard; Passed Assistant Engineer George Cowie, Passed Assistant Surgeon W. H. Rush (recorder), Recorder N. G. Henry, and Master at Arms Jans Petersen, to whose care and vigilance and knowledge of the mechanical portion of the working gear much of the success of the season is due.

Statistics.

Total number of stations occupied	26
Number of current observations with meter	1,557
Number of current observations with pole	1,807
Greatest depth of anchoring at any station (fathoms)	498
Tide station (at Tortugas, Fla.)	1

Very respectfully,

J. E. PILLSBURY,
Lieut. U. S. Navy,
Assistant Coast and Geodetic Survey, Commanding.

Mr. F. M. THORN,
Superintendent Coast and Geodetic Survey.

APPENDIX No. 12.—1886.

THE SECULAR VARIATION OF THE MAGNETIC DECLINATION IN THE UNITED STATES AND AT SOME FOREIGN STATIONS.

[New and greatly enlarged edition.]

By CHARLES A. SCHOTT,
Assistant, Coast and Geodetic Survey.

[Sixth edition, April, 1887.]*

INTRODUCTION.

The practical nature of the inquiry, and the necessity of looking to the publications of the Coast and Geodetic Survey to supply the latest information on the subject of the changes, secular and otherwise, of the direction of the magnetic needle, has caused an ever-increasing demand for these investigations of the survey, and this has acted again as a stimulus to advance our knowledge of the secular changes of the magnetic force, both for direction and intensity. It thus becomes necessary every few years to re-discuss or submit to analysis any additional observations, as well as to direct such observations to be made at those places where they may contribute most effectively towards the elucidation of the laws of change.

Appendix No. 6, Coast and Geodetic Survey Report for 1885, contains an exhaustive article on the secular change of the magnetic dip and the magnetic intensity, as observed in the United States from the earliest to the present time. It is accompanied by three maps, showing the actual distribution of these magnetic elements for the epoch 1885·0. This, together with the present communication, completes the inquiry in this branch of knowledge by bringing it up to date.

During the five years which have elapsed since the last issue of this paper the available material for the discussion of the secular variation of the declination has greatly increased, bringing up the number of stations contained in this edition to 94 and the number of declinations to 1071, for each of which full reference is given, as well as a comparison of the observed and computed values. The average number of observations for a station is 11. It is satisfactory to remark that this increase of observations was found greatly to improve the values of the analytical expressions, giving greater accuracy to the results deduced and tending to greater uniformity in such phases of the secular variation as the amplitude of the motion and the epochs of maxima and minima or times of magnetic elongation, all of which depend on the geographical position of the stations.

* This article originally appeared in Coast Survey Report for 1859, Appendix No. 24, pp. 296–305. In the second edition, in Coast Survey Report for 1874, Appendix No. 8, pp. 72–108, the investigation appears greatly extended; the substitution of a sine for a cosine function was made and the epoch was changed from 1830 to 1850; also some use was made of Cauchy's method of interpolation for the establishment of some second periodic terms. The third edition, issued in June, 1879, appeared in pamphlet form, and is not contained in any annual report of the Coast and Geodetic Survey. The geographical range of the investigation was much enlarged, and the paper was illustrated by two plates. The next or fourth edition was brought out in June, 1881, and forms Appendix No. 9, Coast and Geodetic Survey Report for 1879, then passing through the press; it was illustrated with three plates. In the fifth edition, of November 1882, Appendix No. 12, Report for 1882, there were discussed 837 declinations, observed at 82 stations, situated in the United States and a few in Europe, South America, Asia, and Polynesia, the latter for the purpose of extending our knowledge of magnetic changes beyond our immediate seacoast.

In the collection of observed declinations, as heretofore given, I had sparingly made use of observations taken on board ship, introducing such observations only from necessity, *i. e.*, in the absence of observations on land; but in the present discussion trustworthy observations made at sea have been more freely introduced, and in the case of the great number of observations by Spanish navigators towards the close of the past century, along our Pacific coast, their united testimony has greatly benefited our range of knowledge by giving greater security and unity to results which before appeared doubtful or scattered. The collection of this material is contained in Appendix No. 7, Coast and Geodetic Survey Report for 1885, and was communicated by Assistant G. Davidson. Its value was then conjectural, but the present discussion of it proved to be highly creditable to the navigators of that period. I find the average probable uncertainty* of a declination (variation of compass) observed on board the wooden hulls of those times not to exceed $\pm 1^{\circ}$, the same as I had assigned to the observations taken by Vancouver, an amount which probably represents the best practice of that epoch.

In our own times, for vessels composed of iron and steel, and otherwise largely supplied with such metal, when swung on, say, 8 or 32 equidistant points of the compass, the observed declination will still be subject to a probable uncertainty of about $\pm 0^{\circ}.5$ to $\pm 0^{\circ}.3$

The immediate object of the discussion of the secular change of the declination is to furnish the means of referring observed declinations from one epoch to another, as, for instance, when surveyors are required to re-trace and re-discover old lines originally run by compass, but which had become obliterated in the course of time, or when the variation is demanded for the compasses placed on the sailing, coast, and harbor charts of the survey. The principal demand for the results of this article comes from surveyors and members of the legal profession, and frequently arises from litigation in cases of disputed land boundaries; and since the source where such information could be had became better known, the number of applications to the survey for assistance has increased from year to year.

To facilitate reference to stations and results, the contents of the paper are arranged in three parts—an eastern, middle, and western division—in which the places follow approximately in geographical order; and the final tables, or ephemerides, give the declinations, after the year 1850, for every fifth year, instead of for every tenth as in former editions. To render this investigation more useful to practical men, I have thought it desirable to preface it with a brief account of the *principal* motions, systematic as well as apparently irregular, to which the direction of the magnetic needle has been found subject, in order to clearly separate and distinguish these changes from the secular variation, which last is here the special object of treatment.

The magnetic declination.—The magnetic declination (or variation of the compass, as it was formerly called by surveyors and still is by navigators), at any place, is the angle contained between two vertical planes, one being the astronomical or true meridian, and the other a plane in which the horizontal axis of a freely suspended magnet lies at the time. The former plane is fixed and the latter variable, since it is found that the needle is generally in a state of slow or tremulous motion. The magnetic declination varies with respect to space and time; it is, therefore, necessary to give with the statement of its measure the exact time (year, day, and hour) when an observation was made, as well as the geographical position of the place (the latitude and longitude to the nearest minute of arc will suffice). The declination is called "west" when the *north* end of the magnet points to the west of true north; algebraically this fact is indicated by a + sign, and if "east" by a − sign. It is a matter of observation that the magnet, when light and delicately suspended (by a single fiber of raw silk) is seldom or never at rest, but is always shifting its direction, or is in a state of oscillation or of tremor, or it may be subject to sudden changes. These angular motions have been classified as regular (periodic) and irregular variations, and of these we propose to notice briefly the principal ones, such as may generally be exhibited within the limits of the United States.

The *solar-diurnal* variation consists in a systematic movement of the magnet, having for its period the solar day. Its phases depend on local time and its character is the same for the greater part of the northern hemisphere; viz, about the time of sunrise the *north* end of the needle is

* Used in the sense of probable error in the method of least squares.

generally found approaching to or near its most *easterly* deflection or elongation from the magnetic meridian. This phase happens, for instance, at Philadelphia, on the yearly average, about $7\frac{3}{4}^h$ a. m.; at Key West, Fla., about $8\frac{1}{4}^h$ a. m.; and the same at Madison, Wis. It is subject to an annual variation, being about three-quarters of an hour later in the months when the sun is south of the equator, and about one-half of an hour earlier in the summer months than its yearly average time of occurrence. The north end of the needle then begins its principal daily motion, and reaches the opposite extreme position, or its western elongation, about half past 1 o'clock p. m. It is reached a few minutes earlier in summer and a few minutes later in winter, and hardly varies half an hour for different localities. After this epoch the needle takes up an easterly movement and gradually returns nearly to the direction from which it set out in the morning. Frequently an interruption, or small reversed motion, is exhibited during the night. At Philadelphia the average daily direction is reached in summer about $10\frac{1}{4}^h$ a. m. and in winter about $10\frac{3}{4}^h$ a. m., and generally within half an hour of these times at other places. The magnetic meridian is crossed a second time, generally between 7 and 9 p. m. The angular range between the morning and afternoon elongations, or the diurnal range, is about 8′ on the average at Philadelphia and about $5\frac{1}{2}'$ at Key West; in higher magnetic latitudes it is more, in lower less. This range is subject to an annual inequality, being much more conspicuous in summer than in winter ($10\frac{1}{2}'$ at Philadelphia in August and 6′ in November). It is further subject to a periodic inequality related to the eleven-year cycle of the sun-spots. It is least in years of minimum sun-spots (as in 1878 and 1887 (?), for instance) and greatest in years of maximum sun-spots (as in 1870 and 1883), the factors being 0.7 and 1.3, about, of the average amount of these years respectively. This daily variation appears at times intensified, at other times enfeebled, and during the winter months there are occasionally days on which it cannot be recognized. Observations must be corrected for time of day in order to reduce the result to the average direction of the twenty-four hours; a table given for this purpose is found in Coast and Geodetic Survey Report for 1881, Appendix No. 8, Art. 6.

The *annual variation* of the declination is so small that a mere mention of its existence suffices; its amplitude is at most $1\frac{1}{2}$ minutes of arc.

The *variation* depending on the *solar rotation* has a period of about twenty-six days; its amplitude is likewise small in our latitude.

The lunar inequalities: These we also pass over on account of their small amplitude. The principal inequality is the lunar diurnal variation exhibiting the peculiarity of two maxima and two minima on each lunar day. The range of this inequality at Philadelphia is about 27″, and at Toronto, Canada, about 38″. Other lunar inequalities are of yet smaller order.

The secular variation of the magnetic declination, our subject proper, is most probably also of a periodic character, but since it requires centuries for its full development, and since, as yet, no one cycle has actually been completed within the range of observation, we are obliged, in the absence of any reliable theory, to follow up the phenomena by continuous observations. The secular motion may be compared with a wave motion or with an oscillation of a pendulum which comes to rest momentarily at its extreme positions or elongations and moves fastest midway between these extremes. Smaller variations within this period have also been detected, but the general angular movement (say of the north end) of the magnet may be described as follows: About the times of maximum deflection the magnet appears almost stationary or only slowly oscillating about the same average direction for several years (as observed by ordinary or rough instruments); soon, however, the effect of the secular change becomes perceptible, increasing gradually, year by year; this progressive angular motion soon reaches an annual maximum value, after which, still moving in the same direction, it slowly diminishes in speed and finally becomes again stationary, now at the opposite extreme digression, after which possibly it will return again to its first position. Within the area of the United States and south of latitude 49° a complete oscillation of this kind may require between two and a half and three and a half centuries, during which time the magnet would swing twice, i. e., once forward and once backward, through an arc of several degrees, generally keeping within the limits of 4° and 8° of total range for our geographical boundaries; in other localities the period and range are very much greater. The remarkable regularity of the motion is well shown on the accompanying diagram for Paris, France, for which place we probably possess the longest series of observations; the period is about four and two-third cen-

turies, and the range nearly 33°. To illustrate further the effect of the secular change, we may take the case of New York City. In this locality the needle was observed to be in nearly a stationary condition about 1682, its north end pointing then fully 9° to the west of north; it then moved easterly and reached its easternmost digression about 1799, showing at that time only 4⅓° west declination. Ever since this epoch the motion has been westerly, its present value being nearly 8¼° W.; the greatest annual change (nearly 5′) was apparently passed about the middle of the century. The times of these stationary epochs are different at different localities; the last epoch of eastern elongation was noted earliest in Maine towards the close of the past century, later in the Mississippi Valley, and it has now reached the coast of California and Washington Territory. At present over nearly the whole of the United States the effect of the secular change is to *increase* west declination, or (what is the same) to *decrease* east declination; but on parts of the Pacific coast and for some short distance in the interior the effect is still opposite, viz, an *increase* of east declination. Alaska, however, is to be excepted; there easterly declination is now slowly decreasing. There must, consequently, be a region or belt of no change at present, which will be referred to in detail further on. It is this regular motion, known as the secular variation, which renders it necessary to reconstruct isogonic charts from time to time and to change the compasses and magnetic bearings on our charts. Although this secular variation is perfectly systematic it may not always appear so, especially when deduced from few observations made at different places in the same general locality, either on account of small observing errors or in consequence of local deflections, or for the reason that ordinary periodic variations and inequalities have not been fully eliminated from the results. Among the latter irregularities must be classed the—

Magnetic disturbances or storms.—These may occur at any time, and are, when taken individually, beyond the power of prediction; but attacked by the statistical method, *i. e.*, when classified and when averages are taken of many thousands, they are found to be subject to various laws. Their presence is generally indicated by sudden deflections, and by rapid and great fluctuations in the direction of the needle as compared with its normal position, which otherwise might have been expected at that time of day and month. They often take place simultaneously over distant regions of the globe, and in duration may be confined to a few hours, or they may last a day or even for several days. They are frequently accompanied by auroral lights and by strong electric earth-currents. When analyzed in large numbers they exhibit a solar-diurnal variation, the westerly and easterly disturbances, however, following different laws. They also have an annual variation and seem to depend largely on the sun-spot period or an eleven-year cycle. Irrespective of direction of the disturbing forces the most disturbed hours of the day are generally those between 7^h and 10^h a. m., and the least disturbed those between 2^h and 6^h p. m. Westerly disturbances occur most frequently about 8^h a. m. and least about 8^h p. m.; they exhibit a *single* daily progression. Easterly disturbances reach a maximum about 8^h p. m. and a minimum about 2^h p. m.; they exhibit a *double* daily progression. Westerly and easterly disturbances appear to agree in their annual variation, in their times of maxima, *i. e.*, in August, September, and October, and in their times of minima, *i. e.*, in January and June. The disturbances are most frequent and considerable in the years of maximum sun-spot activity and the reverse in years of minimum sun-spots. The following table of the observed disturbances, in a bi-hourly series at Philadelphia in the years 1840 to 1845, will give an idea of their relative frequency and magnitude:

Deviations from normal direction.	Number of disturbances.
3′.6 to 10′.8	2189
10′.8 to 18′.1	147
18′.1 to 25′.3	18
25′.3 to 32′.6	3
Beyond	0

At Key West, Fla., the maximum deflection noticed between 1860 and 1866 was 21′.4 At Madison, Wis., where the horizontal magnetic intensity is considerably less, very much larger deflections have been noticed. Thus, on October 12, 1877, one of 48′, and May 28, 1877, one of 1° 24′.

We now proceed to the consideration of the secular variation of the magnetic declination.

Historical note.—The following brief historical remarks on the magnetic declination and its secular variation have been prepared from extracts from Humboldt's Cosmos (Otte's translation, London, 1849–1858), Vol's II and V; from the Encyclopædia Britannica, 9th edition, Art. Compass, vol. VI (Boston, 1877), and from E. Walker's treatise "Terrestrial and Cosmical Magnetism," Cambridge (England), 1866, in which works fuller references will be found. The Encyclopædia of Experimental Philosophy, London, 1848, Art. Magnetism, as well as Gehler's Physikalisches Wörterbuch, Leipzig, 1825, Art. Compass, were also consulted.

The first notice of the magnetic needle as applied to navigation we meet with among western (European) nations does not date further back than the eleventh or twelfth century of our era, but in China the directive property of the magnetic needle was made use of on land as early as the twelfth century B. C., and, according to tradition, even at a very much earlier time (2634 B. C.). In the third and fourth centuries of our era Chinese vessels were guided by the magnetic needle, and through them a knowledge of the polarity of the needle was conveyed to India and thence westward. In the ninth century Chinese merchants traded in ships to the Persian Gulf and the Red Sea. Probably through the influence of Arabian navigators, or through the agency of the Crusaders, the use of the mariners' compass was introduced into Eastern Europe. Among the first European writers of the middle ages who refer to the loadstone or to the compass is the Icelandic historian, Are Frode, who lived about the end of the eleventh century. He states that the directive property of the loadstone was then known to seamen in northern countries. Next are mentioned, Alexander Neckam, in two treatises, "De Utensilibus" and "De Naturis Rerum," of the twelfth century, Guyot, of Provins, in 1190, and Jaques de Vitry, between 1204 and 1215. Raymond Lully, in 1272 and 1286, remarks that the seamen of his time employed the magnetic needle, and from Torfæus we learn that the compass was in use among the Norwegians about the middle of the thirteenth century. Among then-western nations the construction of the instrument underwent great improvements, particularly by the hands of Flavio Gioja, of Amalphi, Italy, in 1302.

The declination.—From a Chinese work, written between 1111 and 1117 A. D., we learn that the needle was then suspended by a thread and that the mode of measuring the amount of the declination, it being then west (or, as there expressed, east of south), had long been understood. It can hardly be supposed that the fact of the needle, in general, *not* pointing exactly to the true north and south could have been overlooked in the twelfth century, on the Mediterranean, in places where the declination reached 6° to 10°. A passage interpolated in a Paris MS., a copy of "Epistola Petri Peregrini," &c., of 1269, states the declination to have been determined by him in Italy at 5° E. Columbus probably was the first who records the change in the sign of declination with change of geographical position. On starting from the west coast of Spain he had east declination. In September, 1492, in the Atlantic, in latitude 28° longitude 28° (about) he observed 11° W. He has also the merit of being the first to discover a part of an agonic line, or line of no declination. The first scientific work in Europe in which the declination is treated at any length and deduced from actual observations is that by Boroughs, published in 1581, entitled "A discourse on the Variation of the Cumpas or Magneticall Needle," and is dedicated to the "travaillers and mariners of England." In 1599, Prince Maurice, of Nassau, the lord high admiral of the Low Countries, recommended seamen to keep a register of the declination in every part of the world they might visit.

Isogonic charts.—The declination only was marked on the chart of Andrea Bianco, drawn up in the year 1436, but Alonso de Santa Cruz, in 1530, constructed the first general declination chart, though based upon very imperfect material. Upon the chart by Father Christopher Burrus (who died in 1632), published at Lisbon, the magnetic lines are called "tractus chalyboeliticos." About 170 years after Alonso de Santa Cruz, Edm. Halley published his celebrated isogonic chart for the year 1700, based entirely upon observations. [Tabula Nautica, Variationum Magneticarum Index, juxta observationes anno 1700.] His voyages of the years 1698, 1699, and 1702 were undertaken at the expense of the British Government. This chart comprises the areas of the North and South Atlantic, the Indian, and the extreme western part of the Pacific Ocean. Isogonic charts became quite numerous after Halley's time. Those by Hansteen (Magnetismus der Erde, 1819) deserve special mention; his earliest one is for the year 1600. In 1838 Gauss published his "General theory of Terrestrial Magnetism" (in Resultate, etc., des Magnetischen Vereins, Göttingen) and the result-

ing isomagnetic curves were afterwards charted. A translation of the theory and copies of the charts are given in Taylor's Scientific Memoirs, Vol. II, London, 1841. In the work of A. Erman and H. Petersen, "The Foundation of the Gaussian theory and the phenomena of Terrestrial Magnetism in the year 1829," Berlin, 1874, the general distribution of magnetism over the globe is shown on six charts for the epoch 1829. For the most complete magnetic charts depending directly on observations, the reader is referred to General Sir Edward Sabine's Contributions to Terrestrial Magnetism, Nos. XI, XIII, XIV and XV, Phil. Trans. Roy. Soc., for the years 1868, 1872, 1875 and 1877, respectively. These charts refer to the period 1840 to 1845. The latest isogonic charts for the United States of America, reduced to the epoch 1885.0, will be found in the Coast and Geodetic Survey Report for 1882, Appendix No. 13, in three sheets, Nos. 38, 39, 40.

The secular variation of the declination.—The discovery of the gradual change of the declination, which for any one place had previously been supposed by philosophers to be constant, is due to Gellibrand, of Gresham College, England. In 1635 he published his work, entitled "A discourse mathematicall on the Variation of the Magneticall Needle, together with its admirable diminution lately discovered." He based his conclusions upon the recorded observations of Boroughs (1580), of Gunter (1622), and his own observations (1633–34), showing that in the vicinity of London the direction of the needle had changed in the interval fully 7° to the westward. From this time the fact of the secular variation was completely established, and it remained to later times to determine its extent and develop the law governing this change, and to endeavor to find its cause. That the velocity was not uniform was soon perceived, and the apparent periodic character of the variation was prominently forced upon the attention of observers when the needle reached a stationary condition, as, for instance, in the eastern part of the United States towards the end of the eighteenth century, and then recommenced its motion in a direction *opposite* to that it had before. Similarly at Paris, France, the secular change was westward between the stationary epochs of 1580 (about) and 1812 (about), since which time the needle has commenced retracing its course eastwardly. Nearly midway between such stationary epochs the annual change is observed to be a maximum. See Plate No. 29, upper diagram.

ANALYTICAL EXPRESSION OF THE SECULAR VARIATION OF THE MAGNETIC DECLINATION.

The secular variation can be represented with considerable accuracy by means of a circular harmonic function, as might be expected from the almost unlimited adaptation of such functions to all forms of periodically recurring phenomena, provided a sufficient number of terms are introduced. The formula employed for our purpose may be written—

$$D = \delta + r \sin (\alpha m + c) + r_{,} \sin (\alpha_{,} m + c_{,}) + r_{,,} \sin (\alpha_{,,} m + c_{,,}) + \ldots\ldots$$

Where D = magnetic declination at any time t, positive when west, negative when east.

m = number of years and fractions of a year from an epoch t_0 for which 1850 has been adopted; hence $m = t - 1850.00$

$\alpha\ \alpha_{,}\ \alpha_{,,}\ \ldots$ are factors depending on the adopted periods $p\ p_{,}\ p_{,,}\ \ldots$ of the several terms; so that $\alpha = \frac{360^\circ}{p}$ $\alpha_{,} = \frac{360^\circ}{p_{,}}$ $\alpha_{,,} = \frac{360^\circ}{p_{,,}}$, etc.

Thus to $\alpha = 0.9$, 1.0, 1.2, 1.5 there correspond periods of 400, 360, 300 and 240 years respectively.

$r\ r_{,}\ r_{,,}\ \ldots\ldots$ are parameters or semi-ranges,

$c\ c_{,}\ c_{,,}\ \ldots\ldots$ epochal constants of the several periodic terms.

δ = a constant, representing the average or normal declination about which the periodic fluctuations take place.

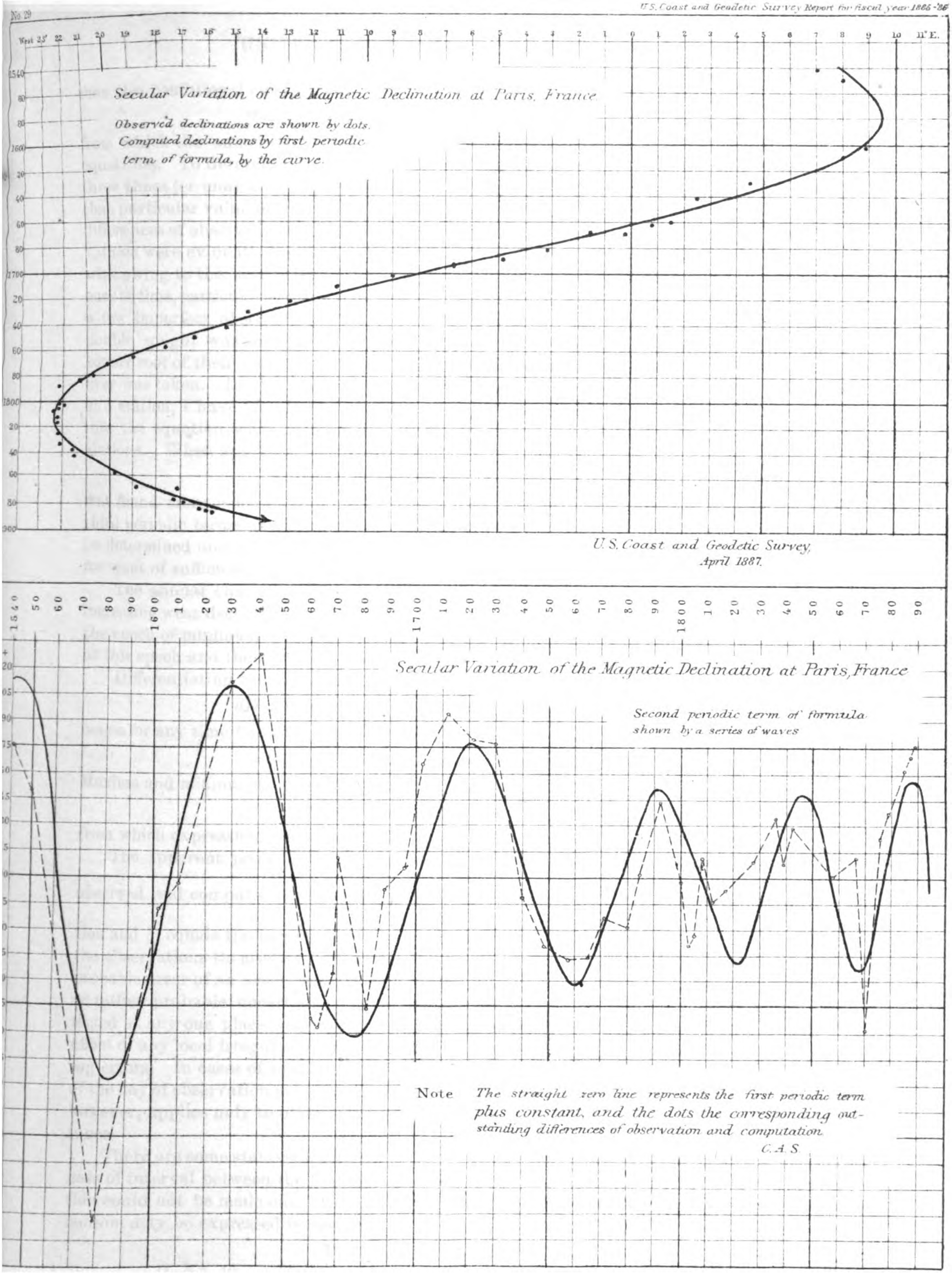
The quantities $\delta,\ r\ r_{,}\ r_{,,}\ \ldots\ \alpha\ \alpha_{,}\ \alpha_{,,}\ \ldots$ and $c\ c_{,}\ c_{,,}\ \ldots$ for any one locality must be determined from the observations made there at various times, and their most probable values are to be deduced by application of the method of least squares.

We begin by assuming a suitable value* for the length of the principal period, and the first periodic term of the formula is treated as follows:

Put $\delta = \delta_{,} + x$ where $\delta_{,}$ = an assumed approximate value of δ and x a correction to it; also put

$$r \cos c = y \quad \text{and} \quad r \sin c = z,$$

* It may be found graphically in the first instance.


No 29
Secular Variation of the Magnetic Declination at Paris, France.
Observed declinations are shown by dots.
Computed declinations by first periodic term of formula, by the curve.
U.S. Coast and Geodetic Survey,
April 1887.
Secular Variation of the Magnetic Declination at Paris, France
Second periodic term of formula shown by a series of waves
Note The straight zero line represents the first periodic term plus constant, and the dots the corresponding outstanding differences of observation and computation.
C.A.S.

then the conditional equations will take the form:

$$0 = \delta_{,} - D + x + \sin \alpha m \cdot y + \cos \alpha m \cdot z + \ldots\ldots\ldots$$

from which the numerical values of x y z are to be deduced in the usual way by means of normal equations. To determine the value of α (and similarly of $\alpha_{,}$ $\alpha_{,,}$ . . .) the computation is repeated three times (or more if necessary) using the slightly changed values $\alpha + \Delta\alpha$ and $\alpha - \Delta\alpha$, from which that particular value of α is found and finally retained which renders the sum of the squares of the differences of observed and computed declinations a minimum. In some cases where certain observations were evidently less trustworthy than others, and which nevertheless could not be dispensed with owing to the small number of observations, or on account of their special value with reference to time, particular weights were assigned; generally each observation received the weight unity, a few imperfect observations the weight one-half, and to some specially valuable observations double weight was assigned. In these cases the conditional equations were multiplied by the square root of their respective weight. Of observations evidently grossly in error no notice whatever was taken. In finally selecting what seemed to be the best expression for the secular change at a station, I have also frequently been guided by the accord of the various constants entering into the equation when compared with corresponding values in the equations for surrounding stations. When applying Cauchy's method of interpolation the form

$$D = \delta + r \cos c \cdot \sin m\alpha + r \sin c \cdot \cos m\alpha + \ldots$$

was found more convenient in use. This method was employed for establishing such second or third periodic terms as appeared demanded by the observations, but only a few such terms could be determined and they generally failed in consequence of the insufficiency in number of data or for want of sufficient accuracy in the observations.

The annual change v of the magnetic declination due to the secular motion, positive when increasing west declination (or decreasing east) and negative when in the opposite direction; also the epoch of minimum west declination (or of maximum east); also the amount of the declination at this epoch and the apparent probable error of an observation—are found as follows:

Differentiating the expression for D, we have

$$dD = r\alpha \cos (\alpha m + c)\, dm + r_{,}\alpha_{,} \cos (\alpha_{,} m + c_{,})\, dm + \ldots\ldots$$

hence for any time t and for minutes of arc,

$$v = 60 \sin 1^{\circ} [r\alpha \cos (\alpha m + c) + r_{,}\alpha_{,} \cos (\alpha_{,} m + c_{,}) + \ldots]$$

Maxima and minima are deduced from the equation:

$$0 = r\alpha \cos (\alpha m + c) + r_{,}\alpha_{,} \cos (\alpha_{,} m + c_{,}) + \ldots\ldots$$

from which expression m can be found.

The apparent probable error e_0 of an observation is deduced from the differences Δ of the n observed and computed declinations by the formula $e_0 = \sqrt{\frac{0.455\ \Sigma\Delta^2}{n - n_{,}}}$, where Σ indicates summation and $n_{,}$ equals the number of unknown quantities in the expression for D, as determined from the observations themselves; when weights p enter, we substitute $p\,\Delta^2$ for Δ^2 and then obtain the probable error of an observation of unit weight. The greater part of this apparent probable error or rather probable uncertainty in the representation is due to the fact that the observations collected at any one place were not generally made at precisely the same spot, thus introducing the effect of any local irregularities in the distribution of magnetism in addition to the ordinary observing errors. In cases of observations evidently not corrected for diurnal variation, with the hour of the day of observation not known, the received imperfect value had to be accepted. This remark, however, applies only to otherwise accurate measures for which alone this correction is of importance.

There are some stations where from want of a sufficient number of observations, or from shortness of interval between the first and last observation, the length of the period of the secular variation could not be made out. In such cases the declination and *annual change* due to the secular motion may be expressed by means of an exponential function, thus:

$$D = d_0 + y\,(t - t_0) + z\,(t - t_0)^2 + \ldots$$

where d_0 = magnetic declination at epoch t_0. I adopt, as in the preceding formulæ, $t_0 = 1850.0$ and put $d_0 = \delta + x$, where δ = an approximate value of d_0 and x a correction to it to be determined, as well as y and z, &c., from the observations themselves. For this purpose we have a number of conditional equations of the form

$$0 = \delta - \mathrm{D} + x + y\,m + z\,m^2 + \;.\;.\;.\;.$$

which equations are to be treated, as customary, by the method of least squares.

Let D = resulting magnetic declination $\left\{ \begin{matrix} + \text{when W} \\ - \text{when E} \end{matrix} \right\}$ for the time t

a = annual change $= y + 2z\,(t - t_0) = y + 2z\,.\,m$; also

T = time of maximum declination $= t_0 - \dfrac{y}{2z}$

In case the change of declination can be represented by a straight line, we have

$\mathrm{D} = d_0 + a\,(t - t_0)$ and the conditional equation will be of the simple form: $0 = d_0 - \mathrm{D} + a\,(t - t_0)$ where d_0 = mean of all observed declinations and t_0 = mean of corresponding times.

The principal uncertainty in the investigation thus arises partly from large observing or instrumental errors in the older observations made with ordinary compasses or with rude instruments generally, and partly, in case of modern observations, since the introduction of more refined instruments (the magnetometer with collimator magnet and theodolite), from change of local positions and from imperfect elimination of irregular variations from the normal direction of the magnet. In consequence of the extended use of iron above and below ground and the rapid growth of cities covering up older stations, it is difficult to select and preserve at such places a suitable locality for permanent use. Accurate investigations of the secular variation can only be made at regular magnetic observatories or in localities exempt from all disturbing influences.

In applying at present a periodic function for the representation of the secular variation,* it should be understood that this *does not necessarily* imply that the phenomenon is a periodic one, or even has an invariable period of the length assigned, or that it must exhibit a second or repeated motions of like character to the first, or even that a first period will be completed without some minor change of law. The aim is simply to represent by a suitable and comprehensive formula the changes which are observed in the direction of the horizontal component of the magnetic force from year to year and during centuries, and to provide the means for the further study of the phenomenon with a view to ascertaining its probable cause, as well as for predicting, at least for a few years in advance, the probable direction of the needle, this information being required in the construction of our hydrographic charts, as well as by the navigator and the surveyor.

The analytical process is thus one of a tentative character and the formulæ are necessarily empirical. Employing a formula of interpolation capable of representing the phenomenon only as far as observed, it would manifestly be unsafe to extend the numerical results either way much beyond the limits of observation. The predictions are here given within proper and safe limits, and these should not be transcended unless the results are sustained by additional observations.

COLLECTION OF OBSERVED MAGNETIC DECLINATIONS SUITABLE FOR THE INVESTIGATION OF THE SECULAR VARIATION.

The material collected for this purpose has been arranged geographically in three groups for greater convenience of reference and of comparison of results. It approximates to an arrangement proceeding from stations of the greatest west declination (at present) to those of greatest east declination, and comprises the whole area of the United States as well as a few foreign locali-

* If we suppose for the moment that the secular variation consists simply of a swing about a mean position, the deflecting force being a maximum at the times of elongation and zero for the epoch midway between, we may obtain some rough evaluation of the magnitude of the horizontal deflecting force when greatest. Thus, at Philadelphia the half-amplitude or the secular deflection either way from the normal equals nearly 3°.3 and the last extreme deflection happened about 1802. At that time, then, the deflecting force corresponded to $\frac{3.3}{57.3} = \frac{1}{17}$ nearly of the normal horizontal force acting in the plane of the meridian. This deflecting force is very much greater than the deflecting force which produces the daily solar variation, the latter being at most, at Philadelphia, for an average amplitude of 8′.0, equal to $\frac{4.0}{3437.7} = \frac{1}{860}$ nearly of the same normal horizontal force.

ties, which were introduced for the special purpose of preparing the way for geographically extending and connecting the laws of the secular change.

Group I comprises stations mainly on the Atlantic coast of the United States and the region east of the Appalachian range.

In particular the stations of this eastern series extend from Newfoundland and Eastern Canada along our Atlantic coast as far south as Florida. Added to these are one station in France, one in the Bermuda Islands, and one in Brazil.

Group II includes stations mainly in the central part of the United States, between the Appalachian and Rocky Mountain systems.

In particular the stations of this central series cover the region south of Hudson Bay and within the United States, including the entire area drained by the Gulf of Mexico. Added to these are two stations in the West Indies and one in Central America.

Group III comprises mainly the Pacific coast stations, and includes the Rocky Mountain region.

In particular the stations are scattered from the Isthmus of Tehuantepec through the western coast States and Territories, including Alaska. To this group are added one station in Siberia and two in the Sandwich Islands.

Each group is treated separately; the record of observations is given first with such notes appended as seemed demanded; then follow the analytical formulæ expressing the secular change, next are given the comparisons between observed and computed values, and the statement of results is completed by decennial tabular values of the declination up to the year 1850, after that the computed values are given for every fifth year, ending with 1895. It is of course to be expected that through future accumulation of data the results may be made more comprehensive and reliable than can be done at present.

GROUP I.—*Series of magnetic stations mainly on the Atlantic coast and in the region east of the Appalachian range.*

The stations of this eastern series are irregularly distributed over the region between Newfoundland and Florida, with one station each in France, in the Bermudas, and Brazil.

Observations were collected and discussed for secular change of declination at the following places:

1. Saint John's, Newfoundland.
2. Charlottetown, Prince Edward Island.
3. Halifax, Nova Scotia.
4. Quebec, Canada.
5. Montreal, Canada.
6. Eastport, Me.
7. Portland, Me.
8. Burlington, Vt.
9. Hanover, N. H.
10. Chesterfield, N. H.
11. Rutland, Vt.
12. Portsmouth, N. H.
13. Newburyport, Mass.
14. Salem, Mass.
15. Boston, Mass.
16. Cambridge, Mass.
17. Provincetown, Cape Cod, Mass.
18. Nantucket, Mass.
19. Providence, R. I.
20. Williamstown, Mass.
21. Hartford, Conn.
22. New Haven, Conn.
23. Albany, N. Y.
24. Oxford, N. Y.
25. New York, N. Y.
26. Bethlehem, Pa.
27. Hatboro', Pa.
28. Philadelphia, Pa.
29. Harrisburg, Pa.

... Tyrone, Pa.

30. Huntingdon, Pa.
31. Chambersburg, Pa.
32. Baltimore, Md.
33. Washington, D. C.
34. Cape Henlopen, Del.
35. Williamsburg, Va.
36. Cape Henry, Va.
37. New Berne, N. C.
38. Charleston, S. C.
39. Savannah, Ga.
40. Milledgeville, Ga.
41. Paris, France.
42. Saint George's Town, Bermuda Islands.
43. Rio de Janeiro, Brazil.

The first column of the record for any station contains the running number of the observed values made use of in the discussion; the second, the date of the observation; the third, the observed value; and the fourth, the name of the observer, the geographical position of the station, the reference to publication, and other pertinent remarks.

GROUP I.—*Collection of Magnetic Declinations observed at various places.*

1.—SAINT JOHN'S, NEWFOUNDLAND.

$\phi = 47° 34'.4$ $\lambda = 52° 41'.9$ W. of Gr.

(Government House.)

		° ′	
1	1700. 0.	15 W.	Edm. Halley's Tabula Nautica; Variationum Magneticarum index, etc., 1700. Greenwich astro'l observations, 1869. [Auxiliary value.—SCH.]
2	1787..	16	E. Walker's "Terrestrial and Cosmical Magnetism," Cambridge, 1866, plate 7, according to Hansteen. [Auxiliary value.—SCH.]
3	1833..	26 30	P. Barlow's isogonic chart, in Phil. Trans. Roy. Soc., 1833, pt. I, p. 668.
4*	1844, October.	29 36	Capt. Bayfield, R. N.; in Phil. Trans. Roy. Soc., 1849, p. 211.
5*	1857, July.	31 21	Capt. Dayman, R. N.; account of deep-sea soundings in the North Atlantic Ocean, 1858, p. 61.
6*	1862, September 11.	31 20	Capt. Orlebar, R. N.
7*	1863, September 22.	31 18	
8*	1864, June 3.	31 00	
9*	1866, April to October.	30 55	Near Government House.
10	1881, June 29.	30 26	Lieut. C. P. Perkins, U. S. S. Alliance; in $\phi = 47° 34'$, $\lambda = 52° 35'$ W. Naval Professional Papers No. 19, Washington, 1886.
	1881, September 26, 27, 28.	30 37.3 W.	Lieut. S. W. Very, N. S. N., Asst. Coast and Geod. Survey. In N. W. corner of grounds surrounding the Government House. [Mean value + 30°.52 for 1881.6; the weight 3 was given to this value.—SCH.]

2.—CHARLOTTETOWN, PRINCE EDWARD ISLAND.

$\phi = 46° 14'$ $\lambda = 63° 27'$ W. of Gr.

		° ′	
1	1833. 0.	19 30 W.	Peter Barlow's isogonic chart for 1833, Phil. Trans. Roy. Soc., 1833, pt. i, p. 668.
2	1842, June.	21 03	Capt. Bayfield, R. N. Letter of Staff-Comdr. F. J. Evans of Jan. 5, 1866; see also Phil. Trans. Roy, Soc., 1849, p. 211.
3	1857, May.	23 02	Capt. Orlebar, R. N. Reference as above.
4	1858, May 18.	22 54	
5	1859, May 20.	22 51	
6	1860, May 17.	22 50	
7	1861, May 14.	22 45	
8	1862, May 27.	23 19	
9	1883, August 29.	24 02	Lieut. J. C. Rich, U. S. S. Alliance; in $\phi = 46° 10'$, $\lambda = 62° 18'$ W. Naval Professional Papers No. 19, Washington, 1886.
	1833, September 22.	24 19 W.	Lieut. R. B. Peck, U. S. S. Swatara; in $\phi = 46° 10'$, $\lambda = 62° 27'$ W. Reference as above. [Mean 24° 10'.5 W., reduction to town −45'; hence decl'n = 23° 26' W.—SCH.]

* The information for the years marked by an asterisk was communicated to the office by Staff-Commander F. J. Evans, hydrographer to the British Admiralty.

Collection of Magnetic Declinations, etc.—Continued.

3.—HALIFAX, NOVA SCOTIA.

$\phi=44° 39'.6$ $\lambda=63° 35'.3$ W. of Gr.

(Naval Yard Observatory.)

		° ′	
1	1604–1612.	16½ W.	According to Champlain's observations at Cape Breton, in Nova Scotia and New Brunswick. At Cape La Heve, the station nearest to Halifax, he observed 16° 15′ W., in $\phi=44°$ 11, $\lambda=64°$ 15′ W. Trans. Lit. and Hist. Soc. of Quebec, session 1864–'65, John Langton, president; Quebec, 1865.
2	1700.0.	13	Edm. Halley's Tabula Nautica; Variationum Magneticarum index, &c., 1700; Greenwich astro'l observations, 1869. [Auxiliary value.—SCH.]
3*	1756..	12 50	From a MS. map by Charles Morris, asst. surveyor.
4*	1775..	13 35	Des Barres' sailing directions.
5*	1798..	16 30	Plan of Halifax, published by Thomas Backhouse.
6*	1818 (?).	17 28	Remark-book of J. Napier, master R. N.; as given by Anthony Lockwood.
7*	1821, June to November.	17 36	Observer as above; observation in June, 17° 38′.2 W.; in Nov., 17° 33′.5 W.
8	1833.0.	17 30	Peter Barlow's isogonic chart for 1833 in Phil. Trans. Roy. Soc., 1833, pt. i, p. 668.
9*	1852–53.	18 10	Capt. Bayfield, magnetic survey.
10*	1852–53.	18 51	Remark-book by J. Hill, master R. N., viz, Aug., 1852, 18° 46′ W.; Sept., 1852, 19° 21′ W., and Aug., 1853, 18° 25′ W. [We adopt, for 1852.7, the mean value 18° 46′ W., and for 1853.2, the value 18° 51′ W.]
11*	1860, July 22.	19 55	Capt. Orlebar, R. N.
12*	1866, April.	21 05.6	Halifax Dock Yard, in $\phi=44°$ 40′, $\lambda=63°$ 25′ W.; declination April 1, at 9 a. m., 20° 55′.0 W.; on April 3, at 3 p. m., 21° 16′.3 W.
13	1873, May 15.	21 35	H. M. S. Challenger, at Drill ground, Dock Yard, in $\phi=44° 39'.8$, $\lambda=63° 35'.2$ W. Report on the scientific results of the voyage of H. M. S. Challenger, etc. Narrative, Vol. II. London, 1882, pp. 26 and 46.
14	1879, September 8, 10.	20 43.3 W.	J. B. Baylor, United States Coast and Geodetic Survey, at southeast end of Dock Yard; in $\phi=44° 39'.5$, $\lambda=63° 35'.0$ W. Coast and Geodetic Survey Report for 1881, Appendix No. 9.

* Observations marked by an asterisk were communicated to the Survey by Staff-Commander Fred. John Evans, R. N.; letters dated January 5, 1886, and April 26, 1887.

4.—QUEBEC, CANADA.

$\phi=46° 48'.4$ $\lambda=71° 14'.5$ W. of Gr.

(Wolfe's Monument.)

		° ′	
1	1642..	16 W.	Padre Bressani; Hansteen's Magnetismus der Erde, 1819; also Trans. of the Lit. and Hist. Society of Quebec, 1865.* [Hansteen's date, 1649, changed to 1642, according to President Langton's art. X of Trans. The weight 0.5 is given to this value.—SCH.]
2	1686..	15 30	De Hayes; Hansteen's Mag. der Erde, 1819.
3	1700.0.	16	Edm. Halley's isogonic chart for 1700, Greenwich observations for 1869.
4	1785..	12 35 W.	Surveyor-General Holland; E. T. Fletcher in Trans. of the Lit. and Hist. Soc. of Quebec, 1865, art. ix.

* I am indebted to Mr. Marcus Baker, of the Computing Division, Coast and Geodetic Survey, for pointing out and procuring this volume for me.

Collection of Magnetic Declinations, etc.—**Continued.**

QUEBEC, CANADA—Continued.

		° ′		
5	1789, June 30.	11 45	W.	Louis Perrault, P. L. S.; reference as above.
6	1791, June 22.	13 00		Pierre Beaupré, P. L. S.; reference as above.
7	1792, March, 24.	12 15		J. B. Demers, P. L. S — Reference as above. [Mean+12°.42 for 1792.3—SCH.]
	1792, May 9.	13 09		A. Dezery, P. L. S
	1792, May 16.	12 00		Ch. Turgeon, P. L. S
	1792, May 16.	12 15		Fr. Legendre, P. L. S.
8	1793--	12 05		Surveyor-General Holland — Reference as above. [Mean+12°.54 for 1793.6—SCH.]
	1793, November 19.	13 00		J. C. Antill, P. L. S
9	1805, April.	11 35		Reg. A, folio 117, Dept. of Crown Lands; reference as above.
10	1810--	11 00		Becquerel's Traité du Magnétisme, Paris, 1846.
	1810, June 5.	12 15		Reg. A, folio 131; E. T. Fletcher, Trans. Lit. and Hist. Soc. of Quebec, 1865. [Mean+11°.62 for 1810.5—SCH.]
11	1811, June.	12 15		Reg. A, folio 143; reference as above.
12	1814--	11 50		Kent, Becquerel's Traité du Magnétisme, Paris, 1846.
13	1820, October 2.	12 30		Bourdages, P. L. S.; E. T. Fletcher, Trans. Lit. and Hist. Soc. of Quebec, 1865.
	1820, November.	12 35		Livingstone, P. L. S.; reference as above. [Mean+12°.54 for 1820.8—SCH.]
14	1821, August, 25.	12 15		Jno. McNaughten, P. L. S — Reference as above. [Mean+12°.90 for 1821.7—SCH.]
	1821, September.	13 00		A. Cattanach, P. L. S
	1821, September.	13 00		W. Ware, P. L. S
	1821, November 28.	13 20		E. Tetu, P. L. S
15	1822, January 21.	13 00		Jos. Hamel, P. L. S — Reference as above.
	1822, January 21.	13 00		Ph. Verrault, P. L. S
	1822, April 26.	13 00		P. J. Bureau, P. L. S
	1822, May.	13 00		Reg. A, folio 162½
16	1823, March 26.	13 00		N. Le François, P. L. S — Reference as above.
	1823, May 12.	13 00		D. S. Ballantyne, P. L. S
	1823, October, 3.	13 00		Jos. Gamahe, P. L. S
	1823, October, 23.	13 00		A. Bochet, P. L. S
	1823, November 14.	13 00		L. Dorval, P. L. S
17	1824, March 2.	12 40		A. Cattanach, P. L. S.; reference as above.
18	1831--	13 38		Captain Bayfield, Becquerel's Traité du Magnétisme, Paris, 1846.
	1831, July 20.	13 10		Thom. Carrol, P. L. S — E. T. Fletcher, Trans. Lit. and Hist. Soc. of Quebec, 1865. [Mean+13°.40 for 1831.7—SCH.]
	1831, autumn.	13 00		Jos. Hamel, P. L. S
	1831, September 6.	14 00		H. Corey, P. L. S
	1831, December 10.	13 12		John Newman, P. L. S
19	1832, May.	13 00		Reg. B, fol. 36; reference as above.
20	1833, May.	12 30		Reg. B, fol. 43 — Reference as above. [Mean+12°.75 for 1833.5—SCH.]
	1833, July.	13 00		Reg. B, fol. 43
21	1834--	14 14		Capt. Bayfield; Trans. Roy. Soc., June, 1872; Gen. Sir Edw. Sabine, Conts. to Terr. Mag., No. xiii.
	1834, March 10.	13 00		Reg. A, fol. 197 — E. T. Fletcher, Trans. Lit. and Hist. Soc. of Quebec, 1865. [Mean+13°.31 for 1834.4—SCH.]
	1834--	13 00		Reg. B, fol. 61
	1834, July.	13 00		Reg. B, fol. 69
22	1835, December.	13 10	W.	Reg. B, fol. 85; reference as above.

Collection of Magnetic Declinations, etc—Continued.

QUEBEC, CANADA—Continued.

		° ′	
23	1838 and 1839.	13 00 W.	Reg. B, fol. 66 — Reference as above. [Mean + 13°.37 for 1839.3—Sch.]
	1839, May.	13 30	Reg. B, fol. 144
	1839	13 35	Reg. B, fol. 154
24	1840, May 20.	13 50	R. M. Moore, P. L. S — Reference as above. [Mean + 13°.71 for 1840.5—Sch.]
	1840, September 14.	13 35	Procès-Verbal, by Jos. Bouchette, D. S. G.
25	1842, December 7.	13 50	Reg. B, fol. 281., Anse des Mères; reference as above — [Mean + 14°.02 for 1842.7—Sch.]
	1842	14 12	Capt. J. H. Lefroy, R. E.; Phil. Trans. Roy. Soc., 1849, part II.
26	1846	14 32	Reg. B, fol. 318, La Canardière; E. T. Fletcher, Trans. Lit. and Hist. Soc. of Quebec, 1865.
27	1847, September 17.	15 30	Reg. B, fol. 316 — Reference as above. [Mean + 14°.64 for 1847.7—Sch.]
	1847, September 20.	14 45	Reg. B, fol. 262
	1847, October, 13.	13 40	Reg. B, fol. 269
28	1848, February.	15 15	Reg. B, fol. 277 — Reference as above. [Mean + 14°.58 for 1848.5—Sch.]
	1848, June 28.	14 00	Reg. B, fol. 299
	1848, October.	14 30	N. Le François, P. L. S., Field-Book C, 50
29	1849, March 8.	15 30	Reg. B, fol. 316 — Reference as above. [Mean + 15°.37 for 1849.4—Sch.]
	1849, July 8.	15 15	Reg. C, fol. 5
30	1850, April.	15 15	Reg. C, fol. 13; reference as above.
31	1851, autumn.	15 00	Reg. C, fol. 33; reference as above.
32	1853, January 19.	15 30	Reg. B, fol. 320; reference as before.
33	1858, October 8.	15 34	Capt. Orlebar, R. N.; communicated by Capt. F. J. Evans, Hydrographic Dept., Admiralty, London.
34	1859, July 19.	16 17	C. A. Schott, Asst. Coast Survey; station near Wolfe's Monument. Coast Survey Report for 1859, p. 296, ϕ and λ as in heading.
35	1860, October 12.	16 28	Capt. Orlebar, R. N.; communicated by Capt. F. J. Evans, Admiralty, London. [This value received double weight.—Sch.]
36	1865	16 40	E. T. Fletcher, surveyor to Dept. of Crown Lands. [This value was given double weight.—Sch.]
37	1879, September 16, 19.	17 13.7 W.	J. B. Baylor, U. S. Coast and Geodetic Survey, in $\phi = 46° 48'.4$, $\lambda = 71° 14'.5$ W.; station of 1859, Coast and Geodetic Survey Report for 1881, App. No. 9. [This value was given double weight.—Sch.]

5.—MONTREAL, CANADA.

$\phi = 45° 30'.5$ $\lambda = 73° 34'.6$ W. of Gr.

(College Observatory, McGill University.)

		° ′	
1	1749	10 38 W.	M. Gillion — V. Colvin, Sup't Adirondack Survey, N.Y., 7th Annual Report, Albany. 1880, p. 492.
2	1785	8 24	Holland, Surv. Gen. of Canada
3	1793, July 26.	8 15	Jer. McCarthey, Trans. Lit. and Hist. Soc. of Quebec, session of 1864-'65, new series; Quebec, 1865, p. 3.
4	1814	7 45	Becquerel's Traité du Magnétisme, Paris, 1846.
5	1834	8 00	Capt. Bayfield; Gen. Sir Edw. Sabine's Conts. No. ix, Phil. Trans. Roy. Soc., 1849; in $\phi = 45° 32'$, $\lambda = 73° 34'$ W.
6	1835	9 50 W.	Reference as for Nos. 1 and 2.

Collection of Magnetic Declinations, etc.—Continued.

5.—MONTREAL, CANADA—Continued.

		° ′	
7	1842, August.	8 57.6 W.	Capt. J. H. Lefroy, R. E. Coast Survey Report for 1855, p. 304. Gen. Sir J. H. Lefroy's Diary of Magnetic Survey, Canada, etc., London, 1883.
8	1859, July 20.	12 21	C. A. Schott, Asst. Coast Survey; Coast and Geodetic Survey Report for 1881, App. No. 9. Grounds of McGill University in $\phi=45° 30'.5$, $\lambda=73° 34'.6$ W.
9	1879, September 25.	13 40.5 W.	J. B. Baylor, Coast and Geodetic Survey. Grounds of McGill University. Report for 1881, App. No. 9.

6.—EASTPORT, ME.

$\phi=44° 54'.4$ $\lambda=66° 59'.2$ W. of Gr.

(Fort Sullivan.)

		° ′		
1	1604–1612.	17 32 W.	Champlain's observation at Douchet Island, St. Croix River. [Information received from asst. H. Mitchell, May 4, 1877.—SCH.]	
2	1700.0.	13	Edm. Halley's isogonic chart, Tabula Nautica; Variationum Magneticarum index, etc., 1700. Greenwich astronomical observations, 1869. [Auxiliary value.—SCH.]	
3	1775--	12 40	At Grand Manan Island; Des Barres, Atlantic Neptune, London, 1781.	
4	1797--	12 19	From a chart, at the mouth of St. Croix, in $\phi=45° 05'$, $\lambda=67° 12'$ W. Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838. [Reduction to Eastport about $-5'$—SCH.]	
5	1833.0.	14 30	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc., 1833.	
	1857, September 16–19.	15 21.1	G. W. Dean, asst. Coast Survey; at Calais, in $\phi=45° 11'.1$, $\lambda=67° 16'.8$ W. Coast Survey Report for 1858, p. 191. [Reduction to Eastport $-12'$, not used.—SCH.]	
6	1860, August to December.	17 57.1	G. B. Vose	Coast Survey observers; at the Fort Sullivan Magnectic Observatory, Coast and Geodetic Survey Report for 1881, App. 9. $\phi=44° 54'.4$, $\lambda=66° 59'.2$ W.
7	1861, January to December.	17 59.2	G. B. Vose and S. Walker	
8	1862, January to December.	18 00.6	S. Walker, R. H. Talcott, E. Goodfellow	
9	1863, January to December.	18 02.3	E. Goodfellow	
10	1864, January to July inclu.	18 03.7	E. Goodfellow, A. T. Mosman, H. W. Richardson	
11	1865, July 22–25.	18 06.1	H. W. Richardson	
12	1873, September 2, 3.	18 56.0	Dr. T. C. Hilgard, observer for Coast Survey; at Fort Sullivan, in $\phi=44° 54'.3$, $\lambda=66° 59'.3$ W. Reference as above.	
13	1879, August 27, 28.	19 07.8 W.	J. B. Baylor, U. S. Coast and Geodetic Survey; at station of 1860. Reference as before.	

7.—PORTLAND, ME.

$\phi=43° 38'.8$ $\lambda=70° 16'.6$ W. of Gr.

(Bramhall Hill.)

		° ′	
	1700.0.	12 25 W.	Edm. Halley's isogonic chart, Tabula Nautica, etc.; Greenwich astronomical observations, 1869. [Not used.—SCH.]

Collection of Magnetic Declinations, etc.—Continued.

7.—PORTLAND, ME.—Continued.

		° ′	
1	1763..	7 45 W.	Prof. John Winthrop; at Falmouth, in $\phi=43° 39'$, $\lambda=70° 19'$ W. Sill. Jour., vol. xvi, 1829; see also Prof. E. Loomis' remarks on the Winthrop table, in Sill. Jour., vol. xxxiv, 1838.
2	1775..	8 30	J. F. W. Des Barres' Atlantic Neptune, London, 1781.
	1833.0.	10 00	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc., 1833. [Not used.—SCH.]
3	1845, June 4.	11 28.3	Dr. J. Locke, in $\phi=43° 41'$, $\lambda=70° 20'$ W.; Smithsonian Contributions to Knowledge, vol. iii, 1852.
4	1851, August 18, 20.	11 41.1	J. E. Hilgard, asst. Coast Survey; at Bramhall Hill, in $\phi=43° 38'.8$, $\lambda=70° 16'.6$ W.; Coast Survey Report for 1854, p. 143.
5	1859, July 15.	12 20	C. A. Schott, asst. Coast Survey; at Bramhall Hill; Coast Survey Report for 1859, p. 296.
	1863, July 6.	12 18.1	C. A. Schott, asst. Coast Survey; at Mount Joy Observatory, in $\phi=43° 39'.9$, $\lambda=70° 14'.9$ W.; Coast Survey Report for 1863, p. 204. [Not used.—SCH.]
6	1863, July 15.	12 28.2	C. A. Schott, asst. Coast Survey; at Bramhall Hill, near station of 1859; Coast Survey Report for 1863, p. 204.
7	1864, August to December.	12 43.7	Prof. H. W. Richardson, observer for U. S. Coast Survey; at Bramhall Hill; monthly determinations on four days each; Coast and Geodetic Survey Report for 1881, App. No. 9.
8	1865, January to December.	12 42.3	
9	1866, January to March incl.	12 42.9	
10	1873, September 8, 9, 11.	12 43.6 W.	Dr. T. C. Hilgard, observer for U. S. Coast Survey; near Mount Joy Observatory; reference as above. [To refer to Bramhall station, add 10′.—SCH.]

8.—BURLINGTON, VT.

$\phi=44° 28'.5$ $\lambda=73° 12'.0$ W. of Gr.

(Coast Survey astronomical station.)

		° ′	
1	1793..	7 38 W.	Dr. Williams; in $\phi=44° 28'$, $\lambda=73° 14'$ W.; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
2	1805..	6 12	J. Johnson, in Thompson's History of Vermont. From repeated comparisons, declination believed by him to be a minimum at this time. [Weight ½ given to this value.—SCH.]
3	1818..	7 30	J. Johnson.. } Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838; in $\phi=44° 28'$, $\lambda=73° 14'$ W.
4	1822..	7 42	J. Johnson..
5	1826..	7 36	Prof. G. W. Benedict; in $\phi=44° 27'$, $\lambda=73° 10'$ W.; Prof. E. Loomis' collection in Sill. Jour., vol. xxxix, 1840.
6	1830..	8 10	J. Johnson.. } Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
7	1831..	8 15	J. Johnson..
8	1832..	8 25	J. Johnson..
9	1834..	8 50	J. Johnson..
	1837..	9 45	Prof. G. W. Benedict; Thompson's History of Vermont. [Perhaps a misprint for 8° 45′; not used.—SCH.]
10	1840..	9 42	J. Johnson; Thompson's History of Vermont.
11	1845, June 26.	9 22 W.	Dr. J. Locke; in $\phi=44° 27'$, $\lambda=73° 10'$ W.; Smithsonian Contributions to Knowledge, vol. iii, 1852.

Collection of Magnetic Declinations, etc.—Continued.

8.—BURLINGTON, VT.—Continued.

		° ′	
12	1855, August 28.	9 57.1 W.	C. A. Schott, asst. Coast Survey; at encampment flag-staff near the lake shore, in $\phi=44°\ 29'.3$, $\lambda=73°\ 13'.4$ W.; Coast Survey Report for 1855, p. 337.
13	1873, October 14, 15.	11 19.0 W.	Dr. T. C. Hilgard, observer for U. S. Coast Survey; in $\phi=44°\ 28'.2$, $\lambda=73°\ 12'.3$; Coast and Geodetic Survey Report for 1881, App. 9.

9.—HANOVER, N. H.

$\phi=43°\ 42'.3$ $\lambda=72°\ 17'.1$ W. of Gr.

(Dartmouth College Observatory.)

		° ′	
1	1765..	7 0 W.	According to President Wheelock, in $\phi=43°\ 41'$, $\lambda=72°\ 10'$ W.; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
2	1810..	4 15	President Wheelock; reference as above.
3	1839..	9 15	Prof. C. A. Young, in $\phi=43°\ 42'$, $\lambda=72°\ 10'$ W.; Prof. E. Loomis' collection in Sill. Jour., vol. xxxix, 1840.
4	1873, October 4–11.	10 49.6	Dr. T. C. Hilgard, observer for U. S. Coast Survey; near observatory; Coast and Geodetic Survey Report for 1881, App. 9.
	1879, October 6.	10 50.5	J. B. Baylor, Coast and Geodetic Survey. This station was the same as that of 1873, a little north of observatory. [Not used.—SCH.]
5	1879, October 7.	11 38.4 W.	Same observer; at a station three-quarters of a mile west of Observatory Hill, in $\phi=43°\ 42'.3$, $\lambda=72°\ 18'.0$ W.; Coast and Geodetic Survey Report for 1881, App. 9.

10.—CHESTERFIELD, N. H.

$\phi=42°\ 53'.5$ $\lambda=72°\ 24'$ W. of Gr.

		° ′	
1	1812..	6 26 W.	Nathan Wilde, observer; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838; position assigned $\phi=42°\ 53'$, $\lambda=72°\ 20'$ W. (applies to entries 1–19)
2	1813..	6 25	
3	1814..	6 17	
4	1815..	6 07	
5	1816..	6 03	
6	1817..	6 02	
7	1818..	6 00	
8	1819..	6 03	
9	1820..	6 00	
10	1821..	6 07	
11	1822..	6 12	
12	1823..	6 30	
13	1824..	6 40	
14	1825..	6 35	
15	1826..	6 35	
16	1827..	6 45	
17	1828..	6 52	
18	1829..	7 00	
19	1830..	7 06 W.	

Collection of Magnetic Declinations, etc.—Continued.

10.—CHESTERFIELD, N. H.—Continued.

		° ′	
20	1831..	7 10 W.	Nathan Wilde, observer; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838; position assigned, $\phi=42° 53'$, $\lambda=72° 20'$ W.
21	1832..	7 15	
22	1833..	7 30	
23	1834..	7 35	
24	1835..	7 40	
25	1836..	7 45	
26	1837..	8 05	A. C. Twining; reference as above.
27	1874, October 4.	10 26.6 W.	Dr. T. C. Hilgard, observer for Coast Survey; in $\phi=42° 54'.0$, $\lambda=72° 26'.0$ W.; Coast and Geodetic Survey Report for 1881, App. 9.

11.—RUTLAND, VT.

$\phi=43° 36'.5$ $\lambda=72° 55'.5$ W. of Gr.

(Post-office.)

		° ′	
1	1789, April.	7 03 W.	Dr. Williams; Sill. Jour., vol. xvi, 1829. [Weight, ½ assigned.—Sch.]
2	1810, May.	6 04	
3	1811, September.	6 01	
4	1859, July 21.	9 49	C. A. Schott, asst. Coast Survey; near new post-office; Coast Survey Report for 1859, p. 296.
5	1873, October 17, 18.	10 40.2	Dr. T. C. Hilgard, observer for U. S. Coast Survey; Coast and Geodetic Survey Report for 1881, App. 9.
6	1879, October 14, 15.	11 09.0 W.	J. B. Baylor, Coast and Geodetic Survey; station of 1873, north and west of post-office, in $\phi=43° 36'.5$, $\lambda=72° 55'.5$ W.; reference as before.

12.—PORTSMOUTH, N. H.

$\phi=43° 04'.3$ $\lambda=70° 42'.5$ W. of Gr.

(New Castle Light-house.)

		° ′	
1	1771..	7 46 W.	Holland, at Kittery, Me., opposite Portsmouth, in $\phi=43° 06'$, $\lambda=70° 45'$ W.; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
	1771..	7 48	Holland, in $\phi=43° 05'$, $\lambda=70° 45'$; reference as above. [Not used.—Sch.]
2	1775..	7 45	J. F. W. Des Barres' Atlantic Neptune, London, 1781.
3	1833.0.	8 45	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc., 1833.
4	1844–45.	9 47	Major Graham; at Boiling Rock; Gen. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., 1872; in $\phi=43° 05'$, $\lambda=70° 45'$ W.
5	1850, August 28, September 2.	10 30.2	J. E. Hilgard, asst. Coast Survey; at Kittery Point, Me.; Coast Survey Report for 1854, p. 143.
6	1859, July 14.	11 15.0	C. A. Schott, asst. Coast Survey; at Kittery Point, Me.; Coast Survey Report for 1859, p. 296.
7	1879, August 13, 14.	12 31.3 W.	J. B. Baylor, U. S. Coast and Geodetic Survey; station of 1850 and 1859, in $\phi=43° 04'.8$, $\lambda=70° 43'.0$ W. of Gr.; Coast and Geodetic Survey Report for 1881, App. 9.

Collection of Magnetic Declinations, etc.—**Continued.**

13.—NEWBURYPORT, MASS.

$\phi=42° 48'.9$ $\lambda=70° 49'.2$ W. of Gr.

(Plum Island Light.)

		° ′	
1	1775..	6 45 W.	J. F. Des Barres' Atlantic Neptune, London, 1781; north of Cape Ann, opposite Newburyport.
2	1781..	7 18	Dr. Williams, in $\phi=42° 48'$, $\lambda=70° 52'$ W. Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
3	1833.0.	8 30	Peter Barlow's isogonic chart for 1833. Phil. Trans. Roy. Soc. for 1833.
4	1850, September 18–20.	10 05.6	J. E. Hilgard, asst. Coast Survey; on Plum Island, in $\phi=42° 48'.0$, $\lambda=70° 48'.8$ W. Coast Survey Report for 1854, p. 143.
5	1859, July 13.	10 58.0 W.	C. A. Schott, asst. Coast Survey; same position as in 1850. Coast Survey Report for 1859, p. 296.

14.—SALEM,* MASS.

$\phi=42° 31'.9$ $\lambda=70° 52'.5$ W. of Gr.

(Fort Lee.)

		° ′	
1	1781, August.	7 02 W.	President Willard, at Beverly, in $\phi=42° 33'$, $\lambda=70° 54'$ W. Mean of seven observations. Sill. Jour., vol. xvi., 1829. [Reduction to Salem—8′.—Sch.]
2	1805, November.	5 57	Dr. Bowditch, in Summer st., Salem; from 115 observations.
3	1808, June.	5 20	Dr. Bowditch, one-eighth of a mile south of above place; from 112 observations.
4	1810, April.	5 47.7 5 13.4	Dr. Bowditch, about one-fourth of a mile east of the place of 1805. [Mean 5° 30′.6—Sch.]
	1810, April, to 1811, May.	6 22.6	Dr. Bowditch, result of a third needle from 5125 observations from monthly means. [Mean of two values, 5° 56′.6 for 1810.8—Sch.]
5	1833.0.	8 30	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc., 1833.
6	1849, August 20.	10 14.5	Prof. G. W. Keely, observer for U. S. Coast Survey; at Fort Lee. Coast Survey Report for 1854, p. 143.
7	1855, August 25.	10 49.7	C. A. Schott, asst. Coast Survey; at Fort Lee. Coast Survey Report for 1855, p. 337.
8	1877.5.	11 30 W.	I. K. Harris, communicated to Superintendent in a letter dated Lynn, Feb. 18, 1878.

* The locality is subject to local magnetic deflections; these disturbances have been traced to and over Cape Ann.

15.—BOSTON, MASS.

$\phi=42° 21'.5$ $\lambda=71° 03'.9$ W. of Gr.

(State-house.)

		° ′	
	1700..	10 W.	Prof. J. Winthrop's table, Sill. Jour., vol. xvi, 1829; also Mem. Am. Acad., vol. ii, new series, Cambridge, 1846. [Prof. E. Loomis has pointed out the observed and interpolated values of the Winthrop table; only the former are used. The table was originally published in the "Boston Boy," July 2, 1764, for which information I am indebted to Mr. J. H. Trumbull.—Sch.]

Collection of Magnetic Declinations, &c.—Continued.

15.—BOSTON, MASS.—Continued.

		° ′	
1	1700.0	10 W.	Edm. Halley's isogonic chart for epoch 1700; reproduced by photolithography in Greenwich astron'l obser's for 1869. [Winthrop's value is supposed to be taken from Halley.]
2	1708..	9	Mathews, observer; Sill. Jour. for 1829, Dr. N. Bowditch. See also Encyclopædia Metropolitana, London, 1848.
3	1741..	7 30	Mathews; Encyclo. Metrop., London, 1848.
4	1775–'76.	7 40	Des Barres' Atlantic Neptune, London, 1871.
5	1782..	7 00	Dr. N. Bowditch; Sill. Jour. for 1829; also first volume of Mem. Am. Acad.
6	1793..	6 30	Mem. Am. Acad., new series, Cambridge, 1846; mean of 1644 observations.
7	1807..	6 05	Communicated by W. Rotch; letter dated Fall River, Feb. 17, 1874.
8	1833.0	8 00	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc. for that year.
9	1839..	9 06	W. C. Bond; at Dorchester, in $\phi=42°\ 19'$, $\lambda=71°\ 04'$ W.; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1840.
10	1846, September 6–8	9 31.4	Lieut. T. J. Lee, asst. Coast Survey; at Dorchester Heights, South Boston, in $\phi=42°\ 20'.0$, $\lambda=71°\ 02'.5$; Coast Survey Report for 1854, p. 143.
11	1855, August 24.	10 13.7	C. A. Schott, asst. Coast Survey, in South Boston; locality as above; Coast Survey Report for 1855, p. 337.
12	1872, September 28, 30; October 1.	11 15.2	A. H. Scott, observer for U. S. Coast Survey; locality as above; Coast and Geodetic Survey Report for 1881, App. 9.
13	1877.5.	11 36	At meridian line on Boston Common, from records at the City Hall, communicated by I. K. Harris, Feb. 18, 1878.
	1884, October 18	11 31 W.	Lt. C. C. Cornwell, U. S. S. Powhatan; at sea, in $\phi=42°20'$, $\lambda=70°\ 47'$ W.; Naval Prof. Papers No. 19, Washington, 1886. [Reduction to Boston harbor uncertain; not used.—SCH.]

16.—CAMBRIDGE, MASS.

$\phi=42°\ 22'.9$ $\lambda=71°\ 07'.7$ W. of Gr.

(Harvard College Observatory.)

		° ′	
1	1708..	9 W.	Brattle, observer; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838; also Mem. Am. Acad., vol. ii, new series, Cambridge, 1846.
2	1742..	8	Prof. J. Winthrop's table; Sill. Jour., vol. xvi, 1829; also Mem. Am. Acad., vol. ii, new series, Cambridge, 1846. [See remarks on the Winthrop table in connection with the Boston series.—SCH.]
3	1757..	7 20	Prof. J. Winthrop; reference as above.
4	1761..	7 14	Dr. Williams; Mem. Am. Acad., vol. ii, new series, Cam., 1846.
5	1763..	7 00	Prof. J. Winthrop; Sill. Jour., vol. xvi, 1829.
6	1780..	7 02	Dr. Williams; Encyclopædia Metropolitana, London, 1848.
7	1782..	6 45	Dr. Williams; reference as above; also Mem. Am. Acad., 1846, where declination 6° 46′ W. is given.
7	1782..	6 44	Prof. Sewall, mean of extremes 6° 21′ and 7° 08′ W.; Sill. Jour. for 1829. See also first vol. of Mem. Am. Acad. [Used 6°.75 W.—SCH.]
8	1783..	6 52	Dr. Williams; Mem. Am. Acad., 1846; also Encycl. Metrop., 1848.
9	1788..	6 38	Dr. Williams; Mem. Am. Acad., 1846.
10	1810..	7 30 W.	Prof. Farrar; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.

Collection of Magnetic Declinations, &c.—Continued.

16.—CAMBRIDGE, MASS.—Continued.

		° ′	
	1833.0.	8 0 W.	Peter Barlow's isogonic chart in Phil. Trans. Roy. Soc., 1833. [Not used.—SCH.]
11	1835..	8 51	Prof. Farrar; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
12	1837..	9 09	Mem. Am. Acad., Cambridge, 1846.
13	1840.4.	9 18	W. C. Bond, director Harvard College Observatory; Mem. Am. Acad., 1846. In $\phi=42° 22'.9$, $\lambda=71° 07'.7$ W.
14	1842.2.	9 34.9	Prof. Jos. Lovering; half-hourly observations during one year, Oct., 1841, to Oct., 1842; Mem. Am. Acad., vol. iv, 1850.
15	1844..	9 39	W. C. Bond, director Harvard College Observatory; MS. communicated by Prof. J. Lovering, of Harvard College.
16	1845, June 2.	9 32	Dr. John Locke, Smithsonian Contributions to Knowledge, vol. iii, 1852.
17	1850, August 9.	9 30	Lieut. J. C. Ives; at Harvard College Observatory; Coast Survey Report for 1856, p. 222.
18	1852..	10 08	W. C. Bond, director Harvard College Observatory; communicated by Prof. J. Lovering in letter of May 29, 1855.
19	1854..	10 39	Observer and reference as before.
	1854, May 10.	9 46	Lieut. J. C. Ives, at Har. Coll. Obs'y; Coast Survey Rep. for 1856, p. 222. [The mean $+10°.21$ is used.—SCH.]
20	1855, May 22, 23.	10 54.6	W. C. Bond, director Har. Coll. Obs'y; communicated by him in letter of Dec. 24, 1858.
21	1856, May 16.	10 50.3	W. C. Bond; reference as above.
	1856, July 17.	10 06	Karl Friesach; at Cambridge Obs'y; results corrected for diurnal variation; Berichte der Kais. Kön. Akademie der Wiss., Vienna, vol. 29, 1858. [The mean $+10°.47$ is used.—SCH.]
22	1859, March.	10 48	Lieut. W. P. Smith, U. S. E.; at Har. Coll. Obs'y; communicated by Capt. G. G. Meade, U. S. E.
23	1866–'67–'68.	10 41	Prof. Jos. Winlock, director Harvard College Observatory; from a large number of observations communicated by him in Nov., 1872. [Computed by me and reduced to mean epoch 1867.5—SCH.]
24	1879, August 7, 9.	11 46.3 W.	J. B. Baylor, U. S. Coast and Geodetic Survey; in the grounds of the Har. Coll. Obs'y, $\phi=42° 22'.8$, $\lambda=71° 07'.6$ W.

17.—PROVINCETOWN, CAPE COD, MASS.

$\phi=42° 03'.1$ $\lambda=70° 11'.3$ W. of Gr.

(Town Hall.)

		° ′	
	1609, July 28.	6 0 W.	Hudson, third voyage; vicinity of Cape Cod. } Prof. E. Loomis, in Sill.
	1609, July 29.	5 30	Hudson; near Cape Cod, at sunset......... } Jour., vol. xxxix, 1840. [These values are probably too small, considering that Champlain found 18° 40′ W. at Malle Barres, now Nauset Inlet, Cape Cod, between 1608 and 1612; but this last value errs probably in the opposite direction. Not used.—SCH.]
1	1609 (?).	12 0 W.	On a map from Dudley's Arcano del Mare, published at Florence in 1646, we have the magnetic declination 12° W. for latitude 42° 30′, longitude 69° W. [This value may refer to the time of Hudson and Champlain, but

Collection of Magnetic Declinations, etc.—Continued.

17.—PROVINCETOWN, CAPE COD, MASS.—Continued.

		° ′ W.	
			must be earlier than 1639, the year of Dudley's death; see Narrative and Crit. Hist. of Am., by Justin Winsor, vol. iii, 1884, p. 303. 12° W. is here adopted.—SCH.] The probable error of this value may be estimated as between 2 and 3°.
2	1700.0.	9 30	Edm. Halley's Tabula Nautica; Variationum, etc. Greenwich Astro'l Observations for 1869.
3	1776..	6 30	At Nantucket, from a chart. Prof. Loomis, in Sill. Jour., vol. xxxix, 1840. [The reduction to Cape Cod may be estimated at +45′, hence referred value 7° 15′ W.—SCH.]
4	1833.0.	8 15	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc., for 1833.
5	1835, September.	9 20	Major J. D. Graham, U. S. Eng. at House Pt. Island, in $\phi=42° 03′$, $\lambda=70° 04′$ W. Government survey of Cape Cod. Sill. Jour., vol. xxxix, 1840; also, Phil. Trans. Roy. Soc., 1849.
6	1860, September 14, 15.	11 23.5 W.	C. A. Schott, assist. Coast Survey; near Town Hall, in $\phi=42° 03′.2$, $\lambda=70° 11′.1$ W. Coast and Geodetic Survey Report for 1881, App. 9.

18.—NANTUCKET, MASS.

$\phi=41° 17′.0$ $\lambda=70° 06′.0$ W. of Gr.

(Mitchell's observatory.)

		° ′	
1	1700.0.	8 15 W.	Edm. Halley's Tabula Nautica, etc. Greenwich Astro'l Observations for 1869.
2	1775..	6 30	J. F. Des Barres' Atlantic Neptune, London, 1781.
	1776..	6 30	From a chart; Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838. [Probably of the same origin as preceding value. Not used.—SCH.]
3	1833.0.	7 30	Peter Barlow's isogonic chart of 1833; Phil. Trans. Roy. Soc., of that year.
4	1834..	8 27	Wm. Mitchell; Sill. Jour., vol. xlvi.
5	1838–'39.	9 02.3	Wm. Mitchell; Sill. Jour., vol. xlvi.
6	1842, August & September.	9 09	Wm. Mitchell; Sill. Jour., vol. xlvi.
7	1843, September.	9 10	Wm. Mitchell; Sill. Jour., vol. xlvi.
8	1846, July 30, 31.	9 14.0	Lieut. T. J. Lee, U. S. E., assist. Coast Survey; near Mitchell's house; Coast Survey Report for 1854, p. 143.
9	1855, August 22.	9 58.3	C. A. Schott, assist. Coast Survey; near Nantucket Harbor light, on beach, in $\phi=41° 17′.5$, $\lambda=70° 06′.0$ W. Coast Survey Report for 1855, p. 337.
10	1867, May 28, 29, 30.	10 19.9	C. O. Boutelle, assist. Coast Survey; at Nantucket Cliff, in $\phi=41° 17′.2$, $\lambda=70° 06′.3$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
11	1879, July 31, August 2.	11 27.9	J. B. Baylor, U. S. Coast and Geodetic Survey; at the Cliff station; reference as above.
12	1883, June 10.	11 38 W.	Lieut. E. S. Prime, U. S. S. Yantic; at sea, in $\phi=41° 29′$, $\lambda=70° 12′$ W. Naval Professional Papers No. 19, Washington, 1886. [Reduction to Nantucket about —12′, hence Dec. = +11°.43—SCH.]

Collection of Magnetic Declinations, etc.—Continued.

19.—PROVIDENCE, R. I.

$\phi=41° 50'.2$ $\lambda=71° 23'.8$ W. of Gr.

(Brown University.)

		° ′	
1	1717..	9 36 W.	R. Jackson, on a map of Providence.
	1720..	9 28	Sill. Jour., vol. xliv, 1843. [The declinations between 1717 and 1843, incl. as given by M. B. Lockwood, civil engineer, are not stated to be from actual observations or from recorded bearings, and I strongly suspect that the table of results here presented is like the Winthrop table, and that for Hatboro', Pa., made up in great part by interpolation. Values 1720 to 1765, incl., not used.—SCH.]
	1725..	9 14	
	1730..	8 54	
	1735..	8 39	
	1740..	8 15	
	1745..	7 59	
	1750..	7 40	
	1755..	7 21	
	1760..	6 57	
	1765..	6 43	
2	1769..	6 30	Dr. B. West. Prof. E. Loomis, in Sill. Jour., vol. xxxiv, 1838.
	1775..	6 20	[See remark above; values 1775 to 1810, incl., not used.—SCH.]
	1780..	6 16	
	1785..	6 13	
	1790..	6 10	
	1795..	6 10	
	1800..	6 15	
	1805..	6 19	
	1810..	6 24	
3	1815..	6 30	M. Brown, B. Lockwood, and G. Shelden.
4	1819..	6 37	[Probably observed by Lockwood.—SCH.]
	1825..	6 51	[See note above; values not used.—SCH.]
	1830..	7 10	
	1833.0.	6 00	Peter Barlow's isogonic chart; Phil. Trans. Roy. Soc., 1833. [Not used.—SCH.]
5	1835..	7 34	
6	1840..	8 25	
7	1841..	8 31	
8	1842..	8 39	
9	1843..	8 46	
10	1855, August 20.	9 31.5	C. A. Schott, assist. Coast Survey, east of Brown University, in $\phi=41° 50'.2$, $\lambda=71° 23'.7$; U. S. Coast Survey Report for 1881, App. 9.
11	1884, June 20.	11 07.7	O. T. Sherman; Report Board of Managers Yale College Obs'y, 1884-'85; in $\phi=41° 50'$, $\lambda=71° 24'$ W.
12	1885, April 11, 13, 14.	11 09.6 W.	J. B. Baylor, U. S. Coast and Geodetic Survey; station east of Brown University, near that of 1855, in $\phi=41° 50'.2$, $\lambda=71° 23'.7$ W. MS. in archives.

Collection of Magnetic Declinations, etc.—Continued.

20.—WILLIAMSTOWN, MASS.

$\phi = 42° 42'.8$ $\lambda = 73° 13'.4$ W. of Gr.

(Astronomical Observatory.)

		° ′	
1	1786..	5 52 W.	Dr. Williams; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
2	1833..	6 15	Prof. A. Hopkins; Prof. E. Loomis' collection, Sill. Jour., vol. xxxix, 1840.
3	1837..	7 45	Prof. A. Hopkins; reference as before.
4	1876, July 28, 29.	10 30.8	F. E. Hilgard, at North Adams, about 4 miles east of Williamstown; in $\phi = 42° 42'$, $\lambda = 73° 08'$ W.; National Academy series, Coast and Geodetic Survey Report for 1882, App. 14.
5	1886, August 22.	10 21 W.	A. Walker and Prof. T. H. Safford; southern part of meridian line of Williamstown College, in $\phi = 42° 42'.8$, $\lambda = 73° 13'.4$ W.; letter of A. Walker, dated Sept. 25, 1886.

21.—HARTFORD, CONN.

$\phi = 41° 45'.9$ $\lambda = 72° 40'.4$ W. of Gr.

(State House.)

		° ′	
1	1786..	5 25 W.	Dr. Williams; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
2	1810..	4 46	Asher Miller, at East Hartford, in $\phi = 41° 46'$, $\lambda = 72° 38'$ W.; reference as above.
3	1824..	5 45	N. Goodwin; reference as before.
4	1828..	6 03	N. Goodwin; reference as before.
4	1829..	6 03	N. Goodwin; reference as before.
5	1859, July 27.	7 17.0	C. A. Schott, asst. Coast Survey, in City Park; Coast Survey Report for 1859, p. 296.
6	1867, August 15, 17.	7 49.3	C. A. Schott, asst. Coast Survey, near the Athenæum, in $\phi = 41° 45'.9$, $\lambda = 72° 40'.4$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
	1875 (?).	8 58	T. C. Ellis, civil engineer. Report Chief of Engineers, U. S. A. In $\phi = 41° 45'$, $\lambda = 72° 40'$ W. [Not used—SCH.]
7	1879, July 24, 25, 26.	8 34.0 W.	J. B. Baylor, U. S. Coast and Geodetic Survey; station of 1859 in City Park, in $\phi = 41° 45'.9$, $\lambda = 72° 40'.5$ W.; Coast and Geodetic Survey Report for 1881, App. 9.

22.—NEW HAVEN, CONN.

$\phi = 41° 18'.5$ $\lambda = 72° 55'.7$ W. of Gr.

(Yale College.)

		° ′	
1	1761..	5 47 W.	President Stiles; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
2	1775..	5 25	Prof. Strong; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
3	1780..	5 15	President Stiles; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
4	1811..	5 10	Nathan Redfield; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
	1818, August.	5 45	Hon. De Witt, Sill. Jour., vol. xvi, 1829. [Not used—SCH.]
	1819..	4 35	Prof. Fisher, of Yale College; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838. [Not used—SCH.]
5	1819, May. 1820, April.	4 25.4 W.	Prof. Fisher, from hourly observations; Sill. Jour., vol. xvi, 1829.

Collection of Magnetic Declinations, etc.—Continued.

22.—NEW HAVEN, CONN.—Continued.

		° ′	
6	1828..	5 17 W.	N. Goodwin; Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
7	1834, November. 1835, November.	5 40.6	Prof. E. Loomis, from hourly observations; Sill. Jour., vol. xxx, 1836.
	1835..	5 52	Prof. E. Loomis' collection of 1838. [Not used—SCH.]
8	1836..	5 55	E. C. Herrick; Prof. E. Loomis' collection of 1838.
9	1837, November.	5 50	E. C. Herrick; Sill. Jour., vol. xxxiv, 1838.
10	1840..	6 10	E. C. Herrick; Prof. E. Loomis' collection, Sill. Jour., vol. xxxix, 1840.
11	1844, August 28.	5 45.1	Prof. J. Renwick, observer for U. S. Coast Survey at Yale College, in $\phi=41° 18'.5$, $\lambda=72° 55'.7$; Coast and Geod. Survey Report for 1881, App. 9.
12	1845, September 10.	6 17.3	Prof. J. Renwick, observer for U. S. Coast Survey at Pavilion Hotel, south of college, near the bay, in $\phi=41° 18'$, $\lambda=72° 54'.6$ W. Reference as above.
	1847, September 25, 28, October 1, 2.	7 27.2	R. H. Fauntleroy, asst. Coast Survey, at Fort Wooster, in $\phi=41° 16'.9$, $\lambda=72° 53'.6$ W. Reference as above. [Local deflection; observation not used—SCH.]
	1848, August 21–29.	7 25.5	J. S. Ruth, subasst. Coast Survey, at Fort Wooster, position and reference as before. [Not used—SCH.]
13	1848, August 10, 12, 14.	6 37.9	J. S. Ruth, subasst. Coast Survey, Pavilion Hotel, position as in 1845. Reference as before.
	1848, August 30, September 1.	6 31.9	J. S. Ruth, subasst. Coast Survey, at Oyster Point, in $\phi=41° 17'.0$, $\lambda=72° 55'.7$ W., in meridian of Yale College. Coast and Geod'c Survey Report for 1881, App. 9. [Used mean, $+6°.58$—SCH.]
14	1855, August 17.	7 02.7	C. A. Schott, asst. Coast Survey at Oyster Point, near position of 1848, in $\phi=41° 16'.9$, $\lambda=72° 55'.8$ W. Reference as above.
	1871, March.	7 22	G. H. Mann, C. E., on College Green, survey of the harbor of New Haven by the U. S. Engineers; MS. communication. [Not used; local deflection suspected—SCH.]
15	1872..	8 27.5	R. M. Bache, asst. Coast Survey; topographic and hydrographic survey of New Haven Harbor and vicinity; from bearings of trigonometrical lines. Hydrographic chart No. 1170.
16	1878, July 18.	8 41.2	Dr. T. E. Thorpe, in Prof. Silliman's garden, in $\phi=41° 18'.7$, $\lambda=72° 55'.6$ W. Proceedings of Royal Society, No. 200, 1880.
17	1884, January to May.	8 50.9	O. T. Sherman, Yale College Observatory grounds, near Silliman's garden, in $\phi=41° 18'.7$, $\lambda=72° 55'.6$. Report to Board of Managers Yale College Obs'y 1884–85. [Mean, $+8°.93$—SCH.]
	1884, June to December.	9 01.0	
	1884, July 22.	8 46.2	O. T. Sherman, at South End, in $\phi=41° 14'.2$, $\lambda=72° 53'$ W. Reference as above. [Not used—SCH.]
18	1885, January to June.	9 00.3 W.	O. T. Sherman, Yale College Observatory grounds. Reference as above.

Collection of Magnetic Declinations, etc.—Continued.

23.—ALBANY, N. Y.

$\phi=42° 39'.2$ $\lambda=73° 45'.8$ W. of Gr.

(State Capitol.)

		° ′	
1	1817, October.	5 44 W.	S. De Witt, surveyor-general; in $\phi=42° 39'$, $\lambda=73° 44'$ W. Sill. Jour., vol. xvi, 1829.
2	1818, August 1.	5 45	
3	1825, April 24.	6 00	
4	1828..	6 14	Geological Report, State of New York, and Sill. Jour., vol. xxxix, 1840.
	1828, September 20.	6 16	
	1828, September 22.	6 18	
5	1830, June 14.	6 18	
6	1831, May 5.	6 25	
	1831..	6 32	
	1831, November 5.	6 40	Regents' Report.
7	1834, October 1.	6 40	Regents' Report and Sill. Jour., vol. xxxiv, 1838.
8	1836, October 29.	6 47	
9	1847, November.	7 35	Regents' Report.
10	1855, August 31.	7 54.7	C. A. Schott, assistant Coast Survey; at Greenbush, opposite Albany, in $\phi=42° 37'.5$, $\lambda=73° 44'.3$ W. Coast Survey Report for 1855, p. 337.
11	1856, September 1.	8 39.2	Karl Friesach, Berichte der Kais. Kōn. Akad., Vienna, vol. 29, 1858. [When corrected for diurnal variations, +8° 35′—SCH.]
12	1858, May 12, 13, 14.	8 17.0	G. W. Dean, assist. Coast Survey, at Dudley Observatory, in $\phi=42° 39'.8$, $\lambda=73° 45'.0$. Coast and Geodetic Survey Report for 1881, Appendix 9.
13	1879, October 21, 24.	9 51.7 W.	J. B. Baylor, U. S. Coast and Geodetic Survey; in grounds of Dudley Observatory, station of 1858. Coast and Geod. Survey Report, 1881, Appendix 9.

24.—OXFORD, CHENANGO COUNTY, N. Y.

$\phi=42° 26'.5$ $\lambda=75° 40'.5$ W. of Gr.

		° ′	
1	1792 to 1795.	3 W.	E. B. McCall, surveyor; in a letter to the Superintendent of the Coast Survey, dated Dec. 22, 1858.
2	1817..	3	E. B. McCall; in $\phi=42° 26'.5$, $\lambda=75° 42'$ W. Reference as above. [Weight ½ given to this value—SCH.]
3	1828, July 7.	4 30	
4	1834, October 9.	3 52	Regents' Report; in $\phi=42° 28'$, $\lambda=75° 33'$ W.; also Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
5	1836, October 5.	4 09	
6	1837..	4 30	Regents' Report of 1839; also Sill. Jour., 1838.
7	1838, July 6.	4 30	At Guilford; in $\phi=42° 24'$, $\lambda=75° 26'$ W. Regents' Report for 1839; also Sill. Jour., 1838. [4° 27′ when reduced to Oxford—SCH.]
8	1849, November 27.	5 11	E. B. McCall; letter to Supt. of Dec. 22, 1858.
9	1857, April 4.	5 44	
10	1858, February 4.	5 47	
11	1858, December.	5 50	
12	1873, December 1.	6 52	Erving Taintor, local surveyor.
13	1874, May 29, 30; June 2, 3, 4, 5, 6.	6 55.7	Dr. T. C. Hilgard, observer for U. S. Coast Survey; on hill about three-fourths of a mile north of railroad depot; in $\phi=42° 26'.5$, $\lambda=75° 40'.5$ W. Coast and Geodetic Survey Report for 1881, Appendix 9.
14	1885, September 23, 24, 25.	7 43.3 W.	J. B. Baylor, subasst. Coast and Geodetic Survey; near Taylor and Scott streets, in $\phi=42° 26'.5$, $\lambda=75° 40'.5$ W. MS. in archives of the Survey.

Collection of Magnetic Declinations, etc.—Continued.

25.—NEW YORK CITY AND VICINITY, N. Y.

$\phi=40° 42'.7$ $\lambda=74° 00'.4$ W. of Gr.

(New York City Hall.)

		° ′		
1	1609, September 1.	2	W.	Hudson, on his third voyage, Sept. 8, found 8° W. on the Jersey shore, a little below the mouth of the Hudson River. The day before he found not above 2° W. A few miles up the Hudson he found, in 1609, Sept. 13, 13° W. Prof. E. Loomis' collection in Sill. Jour., vol. xxxix, 1840; extract furnished by Prof. J. Sparks from 3d vol. of Purchas' Pilgrims. [The known local deflections about the Palisades render the last result of doubtful value, and the first does not appear to possess much probability; the best that may now be done is perhaps to adopt provisionally the value 8° ± 2°—SCH.]
	1609, September 2.	8		
	1609, September 13.	13		
2	1684..	8 45		Philip Welles, surveyor-general. Report of the New York Commissioners on the Connecticut boundary, made to the New York legislature in April, 1857 (Sen. Doc. 165, p. 155). Information received from J. H. Trumbull, April, 1876.
3	1686..	9 00		Geo. Keith, at Sandy Hook; line run between E. and W. New Jersey; records of proprietors of New Jersey. Communicated by Prof. G. H. Cook, State geologist of N. J., Oct. 11, 1879.
4	1691..	8 45		On Staten Island; Geological Survey of New York, 1858. E. Duxbury's patent.
5	1700.0.	8 20		Edm. Halley's isogonic chart for epoch 1700, reproduced by photo-lithography in the Greenwich observations for 1869.
6	1714..	8 45		John Beatty, deputy surveyor; on map of Livingston's manor, New York. Engraved in O'Callaghan's Doc. Hist. N. Y., vol. iii, 414. Received from J. H. Trumbull.
7	1723..	7 20		G. Burnet; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
	1724..	7 20		Cadwalader Colden, one of the commissioners of the New York and Connecticut boundary in 1724. Report of commissioners of 1857. Received from J. H. Trumbull. [The two results are supposed to come from the same source--SCH.]
8	1750..	6 22		Alexander; Prof. E. Loomis' collection in Sill Jour., vol. xxxiv, 1838.
9	1755..	5 00		Evans; reference as above.
	1775.0.	7		J. F. W. Des Barres' Atlantic Neptune, London, 1781; at Sandy Hook. [Not used—SCH.]
10	1789..	4 20		Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838; also Encyclo. Metrop., 1848.
11	1824..	4 40		Blunt's map; Prof. E. Loomis' collection of 1838.
	1833.0.	3		Peter Barlow's isogonic chart. Phil. Trans. Roy. Soc., 1833. [Not used—SCH.]
12	1834..	4 50		Capt. Owen; Prof. E. Loomis' collection of 1838.
13	1837..	5 40		Prof. J. Renwick, at Columbia College (near City Hall). Prof. E. Loomis' collection of 1838.
14	1840, June 16 to July 11.	5 01		Lieut. S. C. Rowan, U. S. N., observer for U. S. Coast Survey; at Howard, Staten Island, in $\phi=40° 37'.6$, $\lambda=74° 05'.4$; Coast and Geodetic Survey Report for 1881, App. 9.
	1840, July 18 to October 16.	5 53	W.	Lieut. S. C. Rowan, U. S. N., observer for U. S. Coast Survey; at Bergen Neck, in $\phi=40° 45'.8$, $\lambda=74° 02'.6$ W. Reference as before. [Mean. +5°.45 for 1840.6—SCH.]

Collection of Magnetic Declinations, etc.—Continued.

25.—NEW YORK AND VICINITY, N. Y.—Continued.

		° ′	
15	1841..	6 06 W.	Douglass' map of New Jersey; Coast Survey archives.
16	1842, September.	5 32.5	Coast Survey observer at Sandy Hook, N. J., in $\phi=40° 27'.7$, $\lambda=74° 00'.2$ W.; Coast and Geod'c Survey Report for 1881, App. 9. [Probable reduction to New York + 22′—SCH.]
	1844, January.	5 51.1	Lieuts. G. M. Bache, and J. Hall, U. S. N., observers for U. S. Coast Survey; at Sandy Hook; reference, position, and reduction as before. [Not used—SCH.]
	1844, August 20, 22.	5 51.0	Prof. J. Renwick, observer for U. S. Coast Survey; at Sandy Hook, N. J.; reference, position, and reduction as before. [Not used—SCH.]
17	1844, August 24.	6 13.1	Prof. J. Renwick, observer for U. S. Coast Survey; at Columbia College (old position), in $\phi=40° 42'.6$, $\lambda=74° 00'.5$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
18	1845, September 4.	6 25.3	Prof. J. Renwick, observer for U. S. Coast Survey; reference and position as before.
19	1846, April 30.	5 09.7	Dr. John Locke, observer for U. S. Coast Survey; at Bloomingdale Asylum, Manhattanville, in $\phi=40° 50'.3$, $\lambda=73° 56'.7$ W.; Coast and Geod'c Survey Report for 1881, App. 9.
	1846, May 4.	5 54.7	Dr. John Locke, observer for U. S. Coast Survey; at Mt. Prospect (formerly Flatbush), Brooklyn, in $\phi=40° 40'.3$, $\lambda=73° 58'.0$. Reference as before. Other observations at this place are given in the Regents' Report of the University of the State of New York, viz: ° ′ / ° ′ Oct. 1834, 4 25 W. / Dec. 22, 1840, 5 00 W. Oct. 1835, 4 45 / Dec. 30, 1841, 5 12 Oct. 1837, 4 45 / Dec. 30, 1842, 5 10 Dec. 18, 1838, 4 45 / Dec. 20, 1847, 5 30 Jan. 4, 1840, 4 55 / Oct. 26, 1848, 5 15 Assigned position $\phi=40° 37'$, $\lambda=73° 58'$ W.
	1846, May 7.	5 37.4	Dr. John Locke, observer for U. S. Coast Survey; at Cole, Staten Island, in $\phi=40° 31'.9$, $\lambda=74° 14'.1$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
	1846, May 14.	5 35.1	Dr. John Locke, observer for U. S. Coast Survey; at Newark, in $\phi=40° 44'.8$, $\lambda=74° 10'.0$ W.; Coast and Geodetic Report for 1881, App. 9. [Mean value, + 5.57 for 1846.3—SCH.]
20	1847, October 16–20.	5 41.0	R. H. Fauntleroy, assistant Coast Survey; at Legget, $\phi=40° 48'.9$, $\lambda=73° 53'.5$ W. Reference as above.
	1855, August 7.	6 39.6	C. A. Schott, assist. Coast Survey; at Governor's Island, in $\phi=40° 41'.5$, $\lambda=74° 01'.1$ W.; Coast and Geod'c Survey Report for 1881, App. 9.
21	1855, August 8.	7 02.1	Observer and reference as above; At Bedloe's (Liberty) Island, in $\phi=40° 41'.4$, $\lambda=74° 02'.7$.
	1855, August 11.	6 28.0	Observer and reference as before; at receiving reservoir (now in Central Park), in $\phi=40° 46'.7$, $\lambda=73° 58'.2$ W. [Mean used, + 6° 43′.2—SCH.]
	1855, August 14.	6 11.2	Observer and reference as before; at Sandy Hook, N. J. Position as in 1842 and 1844. [Not used—SCH.]
22	1860, September 21, 22.	6 44 W.	C. A. Schott asst. Coast Survey; at Mt. Prospect (now Brooklyn new water works), in $\phi=40° 40'.3$, $\lambda=70° 58'.0$ W.; Coast and Geod'c Survey Report for 1881, App. 9.

Collection of Magnetic Declinations, etc.—Continued.

25.—NEW YORK AND VICINITY, N. Y.—Continued.

		° ′	
	1872, October 31, November 1 and 2.	8 45.8 W.	A. H. Scott, U. S. Coast Survey; at Central Park, west of mall, in $\phi=40°$ $46'.2$, $\lambda=73° 58'.2$ W.; reference as above. [Not used; local deflection—SCH.]
23	1873, November 5, 6, 7, 9.	7 09.0	Dr. T. C. Hilgard, observer for U. S. Coast Survey; at Sandy Hook, N. J. Station near that of 1842, '44, '55, $\phi=40° 27'.7$, $\lambda=74 00'.2$ W. [Reduction to New York $+20'$—SCH.]
24	1874, August.	7 23	Report of Chief of Engineers, U. S. A., for 1875; Chart of Way Reef, Hell Gate.
25	1879, July 17, 18.	7 32.0	J. B. Baylor, U. S. Coast and Geod'c Survey; at Sandy Hook, N. J.; station of 1873. [Reduction to New York $+20'$—SCH.]
	1883, August 24.	7 16	Lieut. R. B. Beck, U. S. S. Swatara, in $\phi=40° 29'$, $\lambda=73° 51'$ W. } Naval Professional Papers, No. 19, Washington, 1886.
	1884, May 1.	7 00	Lieut. U. Sebree, G. R. S. Thetis, in $\phi=40° 26'$, $\lambda=73° 51'$ W. } Naval Professional Papers, No. 19, Washington, 1886.
	1884, July 17.	7 34	Lieut. R. B. Beck, U. S. S. Swatara, in $\phi=40° 30'$, $\lambda=73° 50'$ W. } Naval Professional Papers, No. 19, Washington, 1886.
			[Reduction to Sandy Hook, for values of 1883 and 1884, about $-9'$; not used—SCH.]
26	1885, September 30, October 1, 4.	7 52.8	J. B. Baylor, subasst. Coast and Geod'c Survey; at Sandy Hook, N. J., station of 1879. MS. in Coast and Geod'c Survey archives. [Reduction to New York about $+20'$—SCH.]
	1885, October 16, 17, 18.	8 59.7 W.	J. B. Baylor, subasst Coast and Geod'c Survey; in Riverside Park, N. Y., in $\phi=40° 49'$, $\lambda=73° 57'.6$ W. MS. in archives of the Survey. [Not used on account of local deflection—SCH.]

26.—BETHLEHEM, NORTHAMPTON COUNTY, PA.

$\phi=40° 36'.4$ $\lambda=75° 23'.0$ W. of Gr.

(Sayre Observatory, Lehigh University, South Bethlehem.)

		° ′	
1	1757..	6 30 W.	R. W. Walker,* from bearings of old lines. [The weight one-half is given to this value—SCH.]
2	1784..	2 53	Reference as above.*
3	1799..	1 52	Reference as above.* [The weight one-half is given to this value—SCH.]
4	1841, July 23.	3 26	Prof. A. D. Bache, at Easton, 3° 38′.0 W., in $\phi=40° 42'$, $\lambda=75° 15'$ W.; Coast Survey Report for 1862, App. 19. [Reduction to Bethlehem, by isogonic map in Coast Survey Report for 1862, $-12'$—SCH.]
5	1851..	3 50	R. W. Walker,* from bearings of old lines.
6	1874, June 20.	5 19.5	Dr. T. C. Hilgard, near Lehigh University; in $\phi=40° 37'.0$, $\lambda=75 22'.9$ W.; Coast and Geodetic Survey Report for 1881, App. 9. [Position corrected—SCH.]
7	1878.2.	5 37	R. W. Walker,* from bearings of old lines.
8	1881.2.	5 52	Prof. C. L. Doolittle, Lehigh University.*
9	1882.7.	6 05	R. W. Walker,* deduced from 80 observations made by students.
10	1884.0.	6 06 W.	R. W. Walker.*

* This result was given by Mr. R. W. Walker, and communicated to me by Prof. M. Merriman, of Lehigh University, letter of June 7, 1884.—SCH.

Collection of Magnetic Declinations, etc.—Continued.

27.—HATBOROUGH, MONTGOMERY COUNTY, PA.

$\phi=40° 12'$ $\lambda=75° 07'$ W. of Gr.

		° ′		
1	1680..	8 28	W.	Table communicated to the Supt. of the Coast Survey by Mr. E. W. Beans, letter dated Hatboro', March 1, 1852. Coast Survey Report for 1855, p. 312. [It cannot be supposed that this table presents results of direct observation, but likely is the result of some process of interpolation, probably a graphical one. Mr. Beans expressed his entire confidence in the accuracy of the data collected, and I do not doubt that the table is made up from reliable observations of numerous bearings of old (and new) lines. It should also be remembered that at the time this table was communicated our knowledge of the secular variation was very imperfect, and that it was subsequently found to be in good accord with our researches. It is to be regretted that in consequence of Mr. Beans' demise nothing further could be learned of the series—SCH.]
2	1690..	8 15		
3	1700..	7 55		
4	1710..	7 28		
5	1720..	7 00		
6	1730..	6 25		
7	1740..	5 35		
8	1750..	4 55		
9	1760..	4 00		
10	1770..	2 55		
11	1780..	2 05		
12	1790..	1 50		
13	1800..	1 55		
14	1810..	2 00		
15	1820..	2 27		
16	1830..	3 00		
17	1840..	3 50		
18	1850..	4 25	W.	

28—PHILADELPHIA, PA.

$\phi=39° 56'.9$ $\lambda=75° 09'.0$ W. of Gr.

(State House.)

		° ′		
1	1701..	8 30	W.	Observed by Mr. Scull, according to G. Gillet, Sill. Jour., vol. xxiii, 1833.
2	1710..	8 30		Th. Whitney; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
3	1750..	5 45		Kalm's Travels; reference as above.
4	1793..	1 30		Th. Whitney; reference as above.
	1793..	1 30		Mr. Brooks; Sill. Jour., vol. xxiii, 1833.
5	1802..	1 30		Mr. Howell; reference as above.
6	1804..	2 00		By several men of science; reference as before.
	1804..	2 10		Th. Whitney; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
7	1813..	2 25		D. McClure; reference as before.
	1813..	2 27		Th. Whitney; Sill. Jour., vol. xxiii, 1833.
8	1837..	3 52		W. R. Johnson; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
9	1840, June.	3 37		Dr. A. D. Bache, at Girard College Observatory; in $\phi=39° 58'.3$, $\lambda=75° 10'.3$ W. Annual change $=4'.4$ from differential observations between June, 1840, and Dec., 1845; see Coast Survey Reports for 1859, p. 285, and for 1860, p. 311. [Subtracting $5'.3$ from the observed value of 1841 (see further on), we have for June, 1840, the value $+3° 48'$, and subtracting $26'$ from the observed value of 1846 (see further on), we have $+3° 26'$; the mean, or $+3° 37'$, is set down for June, 1840—SCH.]
10	1841, July 20, November 1.	3 53.7	W.	Dr. A. D. Bache, at Girard College Observatory; Coast Survey Report for 1862; magnetic survey of Pennsylvania, p. 213.

Collection of Magnetic Declinations, etc.—Continued.

28.—PHILADELPHIA, PA.—Continued.

		° ′		
11	1846, May 23.	3 51.1	W.	Dr. John Locke, Girard College Magnetic Obs'y; Coast Survey Report for 1854, p. 144.
12	1855, September 5.	4 31.7		C. A. Schott, assist. Coast Survey; grounds east of main building of Girard College, in $\phi=39°\ 58'.4$, $\lambda=75°\ 10'.2$ W.; Coast Survey Report for 1855, p. 337.
13	1862, August 15, 16.	5 00.0		C. A. Schott, assist. Coast Survey; at site of old magnetic observatory, Girard College; in $\phi=39°\ 58'.4$, $\lambda=75°\ 10'.2$ W.; Coast Survey Report for 1862, p. 212.
14	1872, October, 19, 20, 21.	5 27.8		A. H. Scott, U. S. Coast Survey; at site of old magnetic observatory, Girard College; Coast and Geod'c Survey Report for 1881, App. 9.
15	1877, October 2, 3, 5, 6.	6 02.2		J. B. Baylor, U. S. Coast Survey; SW. of main building of Girard College, in $\phi=39°\ 58'.3$, $\lambda=75°\ 10'.3$ W.; Coast and Geodetic Survey Report for 1881, App. 9. [Weight assigned 1½—SCH.]
16	1884, September 3, 10, 11.	6 21.6	W.	Edwin Smith, asst. Coast Survey; in the grounds of Girard College, near chapel, and near site of station of 1877; in $\phi=39°\ 58'.3$, $\lambda=75°\ 10'.3$ W. MS. in archives of the Survey. [Double weight assigned to this value—SCH.]

29.—HARRISBURG, PA.

$\phi=40°\ 15'.9$ $\lambda=76°\ 52.'9$ W. of Gr.

(State Capitol.)

		° ′		
1	1795, August 19.	0 26	E.	From a map of the borough of Harrisburg, on file in office of register and recorder of this county, made by Thos. Foster. Communicated by W. W. Wright, March 10, 1875. [Weight assigned ¼—SCH.]
2	1840, July 25.	3 12.5	W.	Dr. A. D. Bache; in the grounds east of the capitol; Coast Survey Report for 1862, p. 212. [Weight assigned ½—SCH.]
3	1843..	2 35		From a map of the borough of Harrisburg, on file in the city register's office, made by John Roberts. Communicated by W. W. Wright, March 10, 1875.
4	1854, autumn.	3 06		John Roberts and Samuel Hoffer, surveyors; on true meridian established by them east of the State House. Communicated by W. W. Wright, Feb., 1875. [See also Annual Report of Sec'y of Int'l Affairs of Pa. for 1876.]
5	1857, April 29.	3 18.3		James Ferguson, James Aspach, and Daniel Hoffman, surveyors. Results recorded at county commissioner's office. Communicated by W. W. Wright, Feb., 1875.
	1857, June 3.	3 20		Samuel Hoffer; reference as before.
6	1860–'61.	3 30		From surveys made by Hather Page; map in city register's office at Harrisburg. Comm'd by W. W. Wright, March 10, 1875.
7	1862, July, 28, 29.	3 44.5		C. A. Schott, asst. Coast Survey; grounds of the State House, near eastern entrance; Coast Survey Rep. for 1862, p. 212.
8	1874, October and November.	4 51	W.	H. Alricks, jr., J. Simpson Africa; Annual Report of Sec'y of Int'l Affairs of Pa., 1876; W. McCandless, secretary.

Collection of Magnetic Declinations, etc.—Continued.

29.—HARRISBURG, PA.—Continued.

		° ′	
9	1876, December 2.	5 10 W.	Annual Report of the Secretary of State for 1876, as above.
10	1877, September, 25, 26.	4 53.5	Edwin Smith, asst. Coast Survey; grounds east of the capitol, near astronomical station and near station of 1862, in $\phi=40° 15'.8$, $\lambda=76° 52'.9$ W.
11	1885, August 17, 18, 19.	5 21.9 W.	J. B. Baylor, subasst. Coast and Geodetic Survey; station of 1877. MS. in Survey archives.

TYRONE, BLAIR COUNTY, PA.

$\phi=40° 40'$ $\lambda=78° 15'.5$ W. of Gr.

		° ′	
1	1871, September 25.	3 06 W.	Observer W. G. Waring; results communicated by him to the office by letter, dated Tyrone, Pa., April 14, 1879. [Correcting the values for diurnal variation and contracting to yearly means, we have the following results for discussion:
	1871, September 27.	3 12	
2	1873, April 3.	3 24	
	1873, May 10; noon.	3 22	
	1873, June 18; 10 a. m.	3 19	°
3	1874, May 29.	3 20	1871.65 | +3.15
4	1875, June 2.	3 26	1873.36 | 3.35
5	1878, November 6; 10½ a. m.	3 45	1874.41 | 3.33 1875.42 | 3.43
	1878, November 14; 9 a. m.	3 39	1878.88 | 3.70
	1878, November 14; noon.	3 43	1879.21 | 3.80
	1878, December 13; 4 p. m.	3 43.5	The only deduction that can be made at present is for value of annual increase between 1871 and 1880, viz: $+3'.3$—SCH.]
6	1879, March 18; 1 p. m.	3 52 W.	

30.—HUNTINGDON, HUNTINGDON COUNTY, PA.

$\phi=40° 31'$ $\lambda=78° 02'$ W. of Gr.

		° ′	
1	1840, July 30.	1 52.3 W.	Dr. A. D. Bache; Coast Survey Report for 1862, App. 19.
2	1852, April.	2 16	Report of the Secretary of Internal Affairs for 1884–'85, Harrisburg, 1886; J. S. Africa, secretary.
3	1874, August.	3 34	Reference as before.
4	1880, September 24.	4 15.0	
5	1881, June 20.	4 23.4	
6	1883, April 9.	4 33.7	
7	1884, May 26.	4 37.5	
8	1885, December 24.	4 38.0 W.	

31.—CHAMBERSBURG, *FRANKLIN COUNTY, PA.

$\phi=39° 55'$ $\lambda=77° 40'$ W. of Gr.

		° ′	
1	1736, November 4.	4 15 W.	Zachary Butcher.
2	1744, September 11.	3 40	Thomas Cookson.
3	1746, March 25.	3 19	Thomas Cookson.
4	1754--	3 16 W.	From land patent, on various lines, values varying between 2¾° and 4°. Not very reliable.

Collection of Magnetic Declinations, etc.—Continued.

31.—CHAMBERSBURG, FRANKLIN COUNTY, PA.—Continued.

		° ′	
5	1768, May 6, November 1.	1 30 W.	Col. John Armstrong, mean of 1° 15′ and 1° 45′ W.
6	1770, April 25.	1 30	Col. John Armstrong.
7	1786, March 31.	0 15 W.	Mathew Henderson.
8	1787, March 7.	0 15 E.	Mathew Henderson.
9	1794--	0 30	Mathew Henderson; mountain surveys.
10	1807–'8–'9.	0 42.5	Joseph Snively; values between 40′ and 45′ E.
11	1816, November 18.	0 30	Wm. S. Davis.
12	1818, May.	0 22	Wm. Cummins.
13	1822, November 21.	0 15	Wm. S. Davis.
14	1825, December 6.	0 00 E.	Wm. S. Davis.
15	1830, November 5.	0 15 W.	Wm. S. Davis.
16	1836, March 25.	0 27	Wm. S. Davis.
17	1840, August 24.	0 54.4	Dr. A. D. Bache, at Irwin's Mill near Mercersburg, in $\phi = 39° 47′$, $\lambda = 77° 56′$ W.; Coast Survey Report for 1862, App. 19. [Reduction to Chambsburg, + 5′—SCH.]
18	1850, April 29.	1 30	John B. Kaufman; by means of an old, plain compass.
19	1852, April 12.	1 42	Observer and remark as before. [In annual report of the Secretary of Internal Affairs for Pa., Harrisburg, 1886, the value 1° 39′ W. is given--SCH.]
20	1859, October 24.	2 12	John B. Kaufman; by means of a Gurley R. R. compass.
21	1863, March 25.	2 15	John B. Kaufman, notes a very small increase in declination between 1857 and 1863.
22	1864, March 31.	2 19	Observer as above.
23	1865, June 1, 19.	2 24	
24	1866, February 23.	2 25	
25	1867, October to December.	2 35	
26	1869, May 24.	2 40	
27	1871, April, May, June.	2 55	
28	1873, April.	3 00	
29	1876, April.	3 15	
	1876, October.	3 10	Annual Report of Sec. of Int. Aff., Pa., 1876, Harrisburg, 1876. [Mean used—SCH.]
30	1877, June.	3 20	John B. Kaufman; by means of a Gurley solar-transit.
31	1878, April 22.	3 24	John B. Kaufman, at 4 p. m. [Reduction to mean of day, —3′—SCH.]
32	1879, April 12.	3 31	John B. Kaufman, at 3 and 4 p. m. [Reduction to mean of day, — 3′—SCH.]
33	1880, April 19.	3 36	John B. Kaufman, at 3½ p. m. [Reduction to mean of day, —4′—SCH.]
34	1881, April 30.	3 41	John B. Kauffman, at 2 p. m. [Reduction to mean of day, —5′—SCH.]
35	1882, April 29.	3 45	John B. Kauffman, between 11 and 12 a. m. [Reduction to mean of day, —2′—SCH.]
36	1883, April 30.	3 50.5	John B. Kaufman, between 3 and 4 p. m. [Reduction to mean of day, —4′—SCH.]
	1883, October 20.	3 47	John B. Kaufman, at 9 a. m. and 2 p. m., at Upper Strasburg. [Mean of day adopted, 3° 47′ W.—SCH.]
37	1884, April 8.	3 49	John B. Kaufman, at 10 and 11 a. m. [In the Annual Rep. of the Sec'y of Int. Aff. for Pa., the additional value 3° 56′ W. is given—SCH.]
38	1885, April 14	3 53.5	John B. Kaufman, at 11 a. m., at county meridian.
	1885, July 8.	3 55.4 W.	John B. Kaufman, from 20 obse'ns, ten direct and ten reversed, 1 to 2 p. m.; and 3° 53′.5 W. at 6. p. m., two obse'ns. [Corrected mean of 2 days adopted, 3° 52′.5 W.—SCH.]

Collection of Magnetic Declinations, etc.—Continued.

31.—CHAMBERSBURG, FRANKLIN COUNTY, PA.—Continued.

		° ′	
39	1886, March 4.	3 54.0 W.	John B. Kaufman, 3^h 25^m p. m.
	April 6.	3 56.2	John B. Kaufman, 2^h 40^m p. m., 20 ob's in 4 groups.
	April 27.	3 57.0	John B. Kaufman, 10^h 40^m a. m., at county meridian.
	June 4.	3 51.4	John B. Kaufman, 11 a. m., 5 ob's, at 7 a. m., 3° 44′.8, 20 obs's, and 3° 58′.9 at 2 p. m., from 11 ob's; at home meridian, Upper Strasburg, ϕ = 40° 03′, λ = 77° 41′ W.
	October 1.	3 55.5	John B. Kaufman, at 3 p. m., 2 obser's, at county meridian, ϕ = 39° 56′, λ = 77° 39′ W. [Corr'd mean of 5 days adopted, 3° 53′.0 W.—SCH.]
40	1887, January 19.	3 59.2	John B. Kaufman, 11¾ a. m. to 1 p. m; 11 direct and 15 reversed obse'ns.
	January 20.	3 57.6	John B. Kaufman, 11 a. m. and 3° 54′.1, at 9^h 15^m a. m. (11 d. and 12 r. obse'ns); 4° 01′.1, at 1 p. m. (4 obse'ns), and 4° 02′.4 at 3 p. m. (4 obse'ns).
	January 21.	3 53.0	John B. Kaufman, 5 obser's, at 10½ to 11 a. m., 4° 00′ at noon, 4° 01′ at 1 p. m., 4° 05′ at 3 p. m., and 4° 00′ at 5 p. m.
	January 22.	4 00.0	John B. Kaufman, at 11 a. m., 4° 05′ at 0 and 1 p. m., 4° 10′ at 3 p. m., 4° 00′ at 5 p. m.
	1887, March 11.	4 00.5 W.	John B. Kaufman, at 10½ a. m., and 4° 06′ at 2 p. m. [Corr'd mean of 5 days adopted, 4° 00′.0 W.—SCH.]

*This table was obtained from Mr. John B. Kaufman, county surveyor, Franklin County, Pennsylvania, who communicated the same to me in a letter dated "Upper Strasburg, Pa., March 11, 1887." It is headed "Declinations collected by John B. Kaufman, county surveyor, Franklin County, Pennsylvania, partly obtained by differentials between old and new bearings of trustworthy lines, partly by direct observations at the county meridian, latitude 39° 56′, longitude 77° 39′ W., and at the private meridian near Upper Strasburg, in latitude 40° 03′ and longitude 77° 41′ W., about." He further remarks: "From 1736 till 1852 (the declinations are) from land surveys, except the observation of Irwin's Mill; after 1852, partly by well-established lines compared with annual tests at county meridian, till 1876. Since last date observations were recorded from annual tests at private meridian. No correction made for diurnal variation."

32.—BALTIMORE, MD.

ϕ = 39° 17′.8 λ = 76° 37′.0 W. of Gr.

(Washington Monument.)

		°	*Given values.** °		°
1	1679.0.	5.25 W.	D. of 1679.0 = D. of 1814.5 + 4.50		+ 0.75
2	1683.5.	6.25	D. of 1683.5 = D. of 1814.5 + 5.50		+ 0.75
3	1703.5.	5.12	D. of 1703.5 = D. of 1811.8 + 4.43		+ 0.69
4	1720.5.	4.21	D. of 1720.5 = D. of 1816.0 + 3.42		+ 0.79
5	1729.2.	4.02	D. of 1729.2 = D. of 1807.1 + 3.39		+ 0.63
6	1754.5.	2.28	D. of 1754.5 = D. of 1855.5 − 0.37	Adopted value for	+ 2.65
7	1756.9.	2.88	D. of 1756.9 = D. of 1815.0 + 2.12	later epoch.	+ 0.76
8	1771.0.	1.11	D. of 1771.0 = D. of 1846.5 − 1.00		+ 2.11
9	1776.1.	1.75	D. of 1776.1 = D. of 1811.4 + 1.07		+ 0.68
10	1780.5.	0.77	D. of 1780.5 = D. of 1861.5 − 2.25		+ 3.02
11	1787.5.	0.37	D. of 1787.5 = D. of 1851.0 − 2.00		+ 2.37
12	1808.5.	0° 12′.5	D. Byrnes, from numerous observations at Baltimore, in different localities; Sill. Jour., vol. xviii, 1830.		
13	1840, August 27.	2 16.5	Dr. A. D. Bache, Coast Survey Report for 1862, p. 213.		
14	1847, April 29.	2 18.6 W.	Capt. T. J. Lee, U. S. E., assistant Coast Survey, at Fort McHenry, in ϕ = 39° 15′.8, λ = 76° 34′.8 W.; Coast Survey Report for 1854, p. 144.		

Collection of Magnetic Declinations, etc.—**Continued.**

32.—BALTIMORE, MD.—**Continued.**

15	1856, September 13.	2° 29′. 3 W.	C. A. Schott, assistant Coast Survey; just outside Fort McHenry; in $\phi = 39° 15'.9$, $\lambda = 76° 34'.9$ W.; Coast Survey Report for 1858, p. 191.
16	1875. 5.	3. 74	D. of 1875.5 = D. of 1857.0 + 1° 00. Adopted value for 1857.0 + 2°.74.*
17	1877, October 10, 11, 12.	4° 10′. 8	J. B. Baylor, U. S. Coast Survey, at Fort McHenry, near station of 1856, in $\phi = 39° 15'.9$, $\lambda = 76° 34'.9$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
18	1885, August 5, 6, 7.	4 29. 3 W.	J. B. Baylor, subasst. Coast and Geodetic Survey, at Fort McHenry, station of 1877. MS. in archives of Survey.

* Mr. Thomas Kelbaugh, surveyor at Mount Carmel, Baltimore County, Maryland, communicated to the Coast Survey Office (letters dated August 17 and 24, 1877, and April 28, 1879) 52 cases of observed (or allowed for) changes of magnetic declinations between two given dates. These differences were mostly from redeterminations of magnetic bearings of old lines, made with the common surveyor's compass, by different individuals and with different instruments. Their locality was generally within a radius of 15 statute miles of the city of Baltimore, and on the N., the NE., and NW. of it. These surveys were made by order of the Baltimore County circuit court, in consequence of disputed land boundaries. Other values Mr. Kelbaugh copied from the record books of the county surveyor and his assistants, between 1805 and 1825.

[These 52 differential values were carefnlly scrutinized by me and finally combined to 12 mean results, as given in the above table results Nos. 1 to 11 inclusive and No. 16. To these several differences I have added the respective values adopted by me for the declination at the time of the resurvey. These latter data resulted from a formula for Baltimore as established by me in 1877—SCH.]

33.—WASHINGTON, D. C.

$\phi = 38° 53'.3$ $\lambda = 77° 00'.6$ W. of Gr.

(U. S. Capitol, dome.)

		° ′	
	1792..	0 51 E.	Major A. Ellicott, surveyor-general; inscription on fourth mile-stone, northwesterly from east corner of District; reported by G. Mathiot. [Not used—SCH.]
1	1792..	0 19 E.	Major A. Ellicott; inscription on first mile-stone northwesterly from east corner of District; reported by John Wiessner.
1	1792..	0 10 E.	Major A. Ellicott; inscription on east corner-stone of District; reported by J. Wiessner; in $\phi = 38° 53'.6$, $\lambda = 76° 54'.6$ W.
2	1809, December.	0 52 W.	Nicholas King, surveyor for the city of Washington; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
3	1841. 0.	1 20. 2	J. M. Gilliss, U. S.N.; on Capitol Hill, north of the Capitol; in $\phi = 38° 53'.7$, $\lambda = 77° 00'.6$; Sen. Doc. 2d sess., 28th Congress, 1844–'45.
4	1842. 0.	1 23. 9	J. M. Gilliss, U. S. N.; place and reference as before.
5	1855, July.	2 24	C. A. Schott, assist. Coast Survey; on Capitol Hill, near Gilliss' station; in $\phi = 38° 53'.6$, $\lambda = 77° 00'.6$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
6	1856, August 14, 20.	2 21. 4	C. A. Schott, assist. Coast Survey; at old office building on Capitol Hill; in $\phi = 38° 53'.1$, $\lambda = 77° 00'.6$ W.; reference as before.
	1856, August.	2 00. 9	C. A. Schott; in park east of the Capitol, in $\phi = 38° 53'.3$, $\lambda = 77° 00'.5$ W.; reference as before. [Not used—SCH.]
7	1857, March 9.	2 24. 8	W. Read; near Capitol, south side; Coast Survey Report for 1858, p. 196. Communicated by observer.
8	1860, August 16 to September 26.	2 26. 7	C. A. Schott; at Coast Survey office (old building), in $\phi = 38° 53'.1$, $\lambda = 77° 00'.6$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
9	1862, August 18, 19.	2 39. 4	Observer; locality and reference as before.
10	1863, June 18 to July 28.	2 41. 8	Observer; locality and reference as before.
11	1866, November 1.	2 44. 2	Prof. W. Harkness, U. S. N.; grounds of the U. S. Naval Observatory, in $\phi = 38° 53'.7$, $\lambda = 77° 03'.1$ W.; Smithsonian Contributions to Knowledge, No. 239, p. 61, Washington, 1873.

Collection of Magnetic Declinations, etc.—Continued.

33.—WASHINGTON, D. C.—Continued.

		° ′	
12	1867, January to December.	2 48.1 W.	C. A. Schott; at magnetic observatory, corner 2nd street east and C street south, Capitol Hill, in $\phi = 38° 53'.1$, $\lambda = 77° 00'.2$ W.; monthly determinations, Coast Survey Report for 1869, pp. 199–207.
13	1868, January to December.	2 51.2	
14	1869, January to June, inclusive.	2 53.0	
15	1870, June 13, 14, 15.	2 53.6	C. A. Schott; at magnetic observatory, corner 2nd and C streets S. E.; Coast Survey Report for 1870, App. 14.
16	1871, June 14, 15, 16.	2 56.9	
17	1872, June 14, 15, 17.	3 00.0	
18	1873, June 14, 16, 17.	3 00.1	Observer and locality as before.
19	1874, June 13, 15, 16.	3 07.4	Coast and Geodetic Survey Report for 1881, App. 9.
	1874, July 20, 21, 22.	3 05.2	[Mean, 3° 06′.3—SCH.]
20	1875, June 12, 14, 15.	3 15.5	Observer, locality, and reference as before.
21	1876, May 1 and 2.	3 18.8	
22	1877, June 14, 15, 16.	3 42.1	C. A. Schott; at new magnetic observatory near corner of First and B sts. S. E., Capitol Hill, in $\phi = 38° 53'.2$, $\lambda = 77° 00'.4$ W.
	1877, August 17.	3 36.8	A. Braid; U. S. Coast Survey; same locality and reference.
23	1878, June 14, 15, 17.	3 47.5	C. A. Schott; locality and reference as before.
	1878, September 8.	3 43.0	Dr. T. E. Thorpe; locality as above; reference as before.
24	1879, June 9, 10, 11.	3 50.4	Wm. Eimbeck and C. A. Schott, assists. Coast Survey; locality and reference as before.
25	1880, February 23, 24, 25.	3 52.4	Marcus Baker, U. S. Coast and Geode'c Survey; locality as before. MS. in archives.
	1880, April 3.	3 57.2	J. B. Baylor; U. S. Coast and Geode'c Survey; locality as before; Coast and Geodetic Survey Report for 1881, App. 9. [Mean, + 3°.92—SCH.]
	1880, June 12, 14, 17.	3 57.1	
26	1882, June 15, 16, 17.	3 55.4	W. Eimbeck, assist. Coast and Geode'c Survey; locality and reference as before.
27	1883, June 18, July 5.	4 00.2	C. A. Schott, assist. Coast Survey; locality as before. MS. in archives.
28	1884, February 5, 7	3 57.9	J. E. Maxfield, sergeant U. S. Signal Corps; locality and reference as before.
	1884, June 16, 17.	4 05.2	C. A. Schott; locality and reference as before.
29	1885, June 13, 15.	4 11.5	
30	1886, June 14, 15, 16.	4 08.7 W.	

34.—CAPE HENLOPEN, DEL.

$\phi = 38° 46'.7$ λ 75° 05′.0 W. of Gr.

(Light-house.)

		° ′	
1	1609, October 4.	6 W.	Hudson; on the coast of New Jersey, in $\phi = 39° 30'$ } Prof. E. Loomis' collection in Sill. Jour., vol. xxxix, 1840. [The mean latitude is 38° 51′, and the declination 7½° W. may be taken with an estimated probable error of ± 2° at least. It is of very little weight—SCH.]
	1609, August 12.	10	Hudson; off the coast of Maryland, in $\phi = 38° 13'$ }
2	1700.0.	6	Edm. Halley; Tabula Nautica Variationum Magnecticarum, etc. Reproduced by photo-lithography in the Greenwich observations for 1869.
3	1795--	0 55 W.	From Aurora; at Lewiston, in $\phi = 38° 46'$, $\lambda = 75° 08'$ W.; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838. [Position corrected by me—SCH.]

Collection of Magnetic Declinations, etc.—Continued.

34.—CAPE HENLOPEN, DEL.—Continued.

		° ′	
4	1833.0.	1 15 W.	Peter Barlow's isogonic map of 1833; Phil. Trans. Roy. Soc., 1833. [On this map the *name* Cape Henlopen is erroneously placed—SCH.]
	1841, May.	4 42	Barnett; Phil. Trans. Roy. Soc., 1841. [Not used—SCH]
5	1843, October and November.	2 26.0	S. P. Lee, U. S. N., act'g assist. Coast Survey; near the light-house; Coast and Geodetic Survey Report for 1881, App. 9.
6	1846, July 1.	2 45.0	Dr. John Locke, act'g assist. Coast Survey; at Lewis' landing, in $\phi=38°$ $48'.8$, $\lambda=75°$ $11'.9$ W.; reference as above.
7	1856, August 27.	3 03.9	C. A. Schott, assist. Coast Survey; near and southwest of the light-house, in $\phi=38°$ $46'.5$, $\lambda=75°$ $05'.3$ W.; reference as above.
8	1885, July 29, 30, 31.	4 59.6 W.	J. B. Baylor, Subassist. Coast and Geodetic Survey; near light-house, in $\phi=38°$ $46'.7$, $\lambda=75°$ $05'.2$ W. MS. in archives of the Survey.

35.—WILLIAMSBURG, JAMES CITY COUNTY, VA.

$\phi=37°$ $16'.2$ $\lambda=76°$ $42'.4$ W. of Gr.

		° ′	
1	1694..	5 W.	Bishop Madison, president of William and Mary's College; in $\phi=37°$ $15'$, $\lambda=76°$ $35'$ W.; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
2	1780..	0 50 W.	
3	1809..	0 33 E.	
4	1840, January.	0 45 W.	Lieut. Col. Edw. Sabines' isogonic chart for Jany., 1840, in Phil. Trans. Roy. Soc. for 1849, part 1.
5	1874, December 4–9.	2 12 W.	J. B. Baylor, U. S. Coast Survey. In the grounds of the W. & M. College. $\phi=37°$ $16'.3$ $\lambda=76°$ $42'.7$ W.; Coast and Geodetic Survey Report for 1881, App. 9.

36.—CAPE HENRY, VA.

$\phi=36°$ $55'.6$ $\lambda=76°$ $00'.4$ W. of Gr.

(Light-house.)

		° ′	
1	1700.0.	4 W.	Edm. Halley's Tabula Nautica Variationum Magneticarum, etc.
2	1728. March 6.	3	W. Byrd; at head of Currituck Sound, in $\phi=36°$ $33'$. The Westover MS. [Reduction to cape $+20'$, about—SCH]
3	1732..	4 42	W. Hoxton; seven miles from Cape Henry, in $\phi=36°$ $50'$. Hansteen's Magnetismus der Erde, 1819. [Probable reduction to cape $-10'$—SCH.]
	1732..	4 40	Douglass' History; in $\phi=37°$ $07'$, $\lambda=75°$ $50'$ W. Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838. [This is supposed the same as Hoxton's obser'n; not used—SCH.]
	1775..	5 00	J. F. W. Des Barres' Atlantic Neptune, London, 1781. [Not used—SCH.]
4	1809..	0 00	President Madison, at Norfolk, in $\phi=36°$ $51'$, $\lambda=76°$ $19'$ W. Prof. E. Loomis' collection, in Sill. Jour., vol. xxxiv, 1838. [Reduction to cape $-4'$ by obser'ns in 1856, but too doubtful to apply—SCH.]
	1823–'24.	1 32	H. Boye's State map of Va., of 1859. [Not used—SCH.]
5	1832, June 9, 11.	0 45 W.	Prof. J. N. Nicollet; Coast Survey Report for 1864, p. 210.

Collection of Magnetic Declinations, etc.—Continued.

36.—CAPE HENRY, VA.—Continued.

		° ′		
6	1856, September 11, 12.	1 28	W.	C. A. Schott, assist. Coast Survey; near the light-house, in $\phi = 36° 55'.6$, $\lambda = 76° 00'.4$ W.; Coast Survey Rep. for 1856, p. 227.
7	1874, November 26, 27, 28.	2 39.5		Dr. T. C. Hilgard, observer for U. S. Coast Survey; near the light-ho.; Coast and Geodetic Survey Report for 1881, App. 9.
8	1879, May and June.	2 32		Lt. S. W. Very, U. S. N.; from 50 observations at the Rip Raps, in $\phi = 36° 59'.0$, $\lambda = 76° 18'.4$ W. MS. communication. [Reduction to Cape Henry about $+10'$.—SCH]
9	1881, June 16.	3 11		Lieut. C. P. Perkins, U. S. S. Alliance; in $\phi = 37° 00'$, $\lambda = 76° 10'$ W.; Naval Professional Papers No. 19. [Reduction to cape $+5'$, about—SCH.]
10	1883, January 2.	3 10		Lieut. G. A. Norris, U. S. S. Enterprise; in $\phi = 36° 56'$, $\lambda = 76° 06'$ W.; reference as before. [Reduction to cape about $+5'$—SCH.]
	1883, June 30.	3 06		Lieut. C. Belknap, U. S. S. Vandalia; in $\phi = 36° 57'$, $\lambda = 76° 02'$ W.; reference as before. [Reduction to cape about zero—SCH.]
	1883, August 29.	3 35		Lieut. H. W. Lyon, U. S. S. Galena; in $\phi = 36° 54'$, $\lambda = 75° 54'$ W.; reference as before. [Reduction to cape about $-5'$—SCH.]
	1883, December 10.	3 39		Lieut. C. Belknap, U. S. S. Vandalia; in $\phi = 36° 56'$, $\lambda = 75° 57'$ W.; reference as before. [Reduction to cape about zero; mean, $+3° 22'$ for 1883.5—SCH.]
11	1884, May 10.	3 37		Lieut. F. Hanford, U. S. S. Pensacola; in $\phi = 36° 54'$, $\lambda = 75° 45'$ W.; reference as before. [Reduction to cape about $-15'$—SCH.]
	1884, October 10.	2 55	W.	Lieut. C. C. Cornwell, U. S. S. Powhatan; in $\phi = 37° 00'$, $\lambda = 76° 06'$ W.; reference as before. [Red'n to cape about $+5'$; mean, $+3° 11'$ for 1884.5—SCH.]

37.—NEW BERNE, N. C.

$\phi = 35° 06'$ $\lambda = 77° 02'$ W. of Gr.

		° ′		
1	1796..	2 40	E.	Jonath. Price; from Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838; position assigned $\phi = 35° 20'$ $\lambda = 77° 05$ W. [Latitude 14′ too high—SCH.]
2	1806..	2 00	E.	
3	1809..	1 45	E.	
4	1840.0.	0 00		Lieut. Col. Edw. Sabine; isogonic chart for 1840, Jan'y; Phil. Trans. Roy. Soc., 1849, part i.
5	1874, December 21, 23, 24.	1 20.4	W.	J. B. Baylor, aid U. S. Coast Survey; at cemetery in $\phi = 35° 07'.4$, $\lambda = 77° 03'.3$ W.; Coast and Geodetic Survey Report for 1881; App. 9.

38.—CHARLESTON, S. C.

$\phi = 32° 46'.6$ $\lambda = 79° 55'.8$ W. of Gr.

(St. Michael's Church.)

		° ′		
1	1700.0.	0 30	E.	Edm. Halley's isogonic chart for 1700, reproduced by photo-lithography in the Greenwich observations for 1869. [Weight ½ in discussion—SCH.]
	1742..	5 23	E.	English Pilot, published at Tower Hill in 1794; extracted from a paper by Andrew Hughes. [Not used—SCH.]

Collection of Magnetic Declinations, etc.—Continued.

38.—CHARLESTON, S. C.—Continued.

		° ′		
2	1775--	3 48	E.	J. F. W. Des Barres' Atlantic Neptune, London, 1781.
	1777--	3 48		From a chart. Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838. [Supposed the same as that given in the Neptune; not used—SCH.]
3	1784, February.	5 15		Joseph Purchell, surveyor. From a pamphlet by Charles Parker, Charleston, 1849. Observations said to come from a reliable source.
4	1785, October.	5 45		
5	1824-'25.	3 45		Lieut. Sherburne, U. S. N.; Blunt's chart of 1824-'25.
6	1833.0.	4 00		Peter Barlow; isogonic chart for 1833. Phil. Trans. Roy. Soc., 1833, part I.
7	1837--	2 54		Capt. Missroom; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838. Position in $\phi=32° 47'$, $\lambda=79° 57'$ W.
8	1840--	2 44		Dr. C. Davies, in his treatise on surveying.
9	1841, May.	2 24		Barnet, Phil. Trans. Roy. Soc., vol. for 1849.
10	1847, October.	2 15		Charles Parker; from a pamphlet published by him at Charleston, 1849.
11	1849, April 1-22.	2 16.5		C. O. Boutelle, assist. Coast Survey; at Breach Inlet, on Sullivan's Island, in $\phi=32° 46'.3$, $\lambda=79° 48'.9$ W.; Coast Survey Report for 1854, p. 145.
12	1874, May 27, 28, 29.	0 58.2		C. O. Boutelle, asst. Coast Survey; at Fort Marshall, near Breach Inlet, in $\phi=32° 46'.4$, $\lambda=79° 48'.8$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
13	1880, January 21, 22.	0 25.6		J. B. Baylor, U. S. Coast and Geodetic Survey; position and reference as before.
14	1885, December 29, 39.	0 14.2	E.	J. B. Baylor, subassist. Coast and Geodetic Survey; near Breach Inlet, Sullivan's Island, in $\phi=32° 46'.3$, $\lambda=79° 48'.9$ W. MS. in archives of the Survey.

39.—SAVANNAH, GA.

$\phi=32° 04'.9$ $\lambda=81° 05'.5$ W of Gr.

(Savannah Exchange.)

		° ′	E.	
1	1817--	4		Becquerel's Traité du Magnétisme, Paris, 1846; Cartes du Dépôt; in $\phi=32° 04'$, $\lambda=81° 05'$ W.
2	1833.0.	5 00		Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc., 1833, part. I.
3	1838--	5 05		Geological Survey; in $\phi=32° 05'$, $\lambda=81° 07'$ W.; Prof. E. Loomis' collection in Sill. Jour., vol. xxxix, 1840.
4	1839--	3 31		Dr. Posey; reference as before.
5	1852, April 26, 27, 28.	3 40.3		J. E. Hilgard, asst. Coast Survey; on Hutchinson's Island, opposite Savannah, in $\phi=32° 05'.2$, $\lambda=81° 05'.3$ W.; Coast and Geodetic Survey Report for 1881, Appendix 9.
6	1857, May 1, 2.	3 27.5		C. A. Schott, asst. Coast Survey; position as in 1852; Coast and Geodetic Survey Report for 1881, Appendix 9.
7	1874, March 8, 9, 10.	2 16.9		F. Blake and C. Tappan, observers for U. S. Coast Survey; position as in 1852 and 1857; reference as above.
8	1886, January 6, 7.	1 37.2	E.	J. B. Baylor, subasst. U. S. Coast Survey; on Hutchinson's Island; position as above. MS. in archives of Survey.

Collection of Magnetic Declinations, etc.—Continued.

40.—MILLEDGEVILLE, GA.

$\phi = 33^\circ\ 04'.2$ $\lambda = 83^\circ\ 12'$ W. of Gr.

		° ′		
1	1805..	5 30	E.	J. Bethune; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838. Position assigned, $\phi = 33^\circ\ 07'$, $\lambda = 83^\circ\ 20'$ W.
2	1835..	4 40		Observer and reference as above.
3	1838..	5 51		Geological Survey of Georgia; Prof. E. Loomis' collection in Sill. Jour., vol. xxxix, 1840. Position assigned, $\phi = 33^\circ\ 07'$, $\lambda = 83^\circ\ 20'$ W.
4	1875, June 18.	3 03.5	E.	J. M. Poole, Bache Fund observer to National Academy of Sciences; Coast and Geodetic Survey Report for 1882, App. 14, pp. 402 and 425; in the old Capitol grounds. [The value given in this report is 4° 14′.1 E. on June 15; this value is one of two obtained by the observer, and is probably affected by a misreading of 1°; the value given by me is his second one, taken from the MS. computation—SCH.]

41.—PARIS, FRANCE.

$\phi = 48^\circ\ 50'.2$ $\lambda = 2^\circ\ 20'.2$ E. of Gr.

(Paris Astro'l Observatory.)

		° ′		
1*	1541..	7	E.	Bellarmatus.
2	1550..	8		Orontius Finæus (Oronce Finné).
3	1580..	11 30		Sennertus.
4	1603..	8 45		Nantonnier.
5	1610..	8 00		Nantonnier.
6	1630..	4 30		Petit.
7	1642..	2 30		Petit.
8	1659 and 1660.	1 30		(?)
9	1664..	0 40	E.	Picard.
10	1666 and 1667.	0 08	W.	Picard.
11	1670..	1 30		Picard.
12	1680–81–82–83–84.	3 08		Picard and La Hire.
13	1685–86–87–88–89.	4 52		La Hire and Cassini.
14	1691–92–93–95–96–97–98.	6 37		La Hire and Cassini. [Mean of 2 values of 1698 included—SCH.]
15	1699, 1700–1–2–3–4, 1705–6–7.	9 00		La Hire and Cassini. [Includes mean of 2 values each for 1700–1–2–3–4, and of 3 values for 1705—SCH.]
16	1708–9–10–11–12–13–14–15–16.	11 11		La Hire and Cassini. [One value for 1715, 3 for 1716, and 2 values each for other years—SCH.]
17	1717–18–19–20–21–22–23–24–25.	12 52		Cassini, La Hire, and Maraldi. [Two values for 1717–18–21–22–23, 3 for 1725, and 1 for 1719–20–24—SCH.]
18	1726–27–28–29–30–31–32–33–34.	14 37		Maraldi and Buache. [Two values for 1734—SCH.]
19	1735–36–37–38–39–40–41–42–43.	15 23		Maraldi and Cassini. [Two values for 1735–36–38–40–42 each—SCH.]
20	1744–45–46–47–48–49–50–51–52.	16 37	W.	Fouchy.

*The values Nos. 1 to 30, inclusive, between 1541 and 1807, except for 1805, were taken from the article "Magnetism," by Peter Barlow, in the Encyclopædia of Experimental Philosophy (a part of the Ency. Metropolitana), London, 1848. [These values were combined by me into suitable groups, and their means were taken as indicated in the table—SCH.]

Collection of Magnetic Declinations, etc.—Continued

41.—PARIS, FRANCE—Continued.

		° ′	
21	1753–54–55–57–58–59–60.	17 49 W.	Maraldi.
22	1765..	19 00	
23	1770–71–72–73–74.	20 01	Maraldi and Le Monnier. [Two values each for 1772–73–74—SCH.]
24	1777–78–79–80–81.	20 40	Le Monnier. [Two values for 1778, 6 for 1779, 46 for 1780, and 12 for 1781—SCH.]
25	1782–83–84–85–86.	21 25	Le Monnier. [Three values for 1782–83 each, and 2 for 1784–86 each—SCH.]
26	1789–90–91–92–93.	22 18	Le Monnier. [Two values for 1790–91 each—SCH.]
27	1798–99–1800–01.	22 14	Le Monnier. [Two values for 1799—SCH.]
28	1802–3–4.	21 58	Le Monnier, Bouvard, and Cotte. [Three values for 1802—SCH.]
29	1805..	22 05	Cotte; E. Walker, in "Terrestrial and Cosmical Magnetism," Cambridge, 1866.
30*	1807..	22 34	Bouvard.
31	1810, March 13, 1 p. m.	22 16	Observations by Arago; Walker's Ter. and Cos. Magnetism, Cambridge (Eng.), 1866. [Mean of 4 values, 22° 24′.5; same corrected for diurnal variation, 22° 20′; epoch, 1812.2—SCH.]
	1811, October 15, noon.	22 25	
	1812, October 9, 2½ p. m.	22 29	
	1813, October 30, noon.	22 28	
32	1814, August 10, noon.	22 34	Observations by Arago; Walker's Ter. and Cos. Magnetism, Cambridge (Eng.), 1866. [Mean of 3 values, 22° 26′.0; same corrected for diurnal variation, 22° 22′; epoch, 1816.5—SCH.]
	1816, October 12, 3 p. m.	22 25	
	1817, February 10, 0½ p.m.	22 19	
33	1823..	22 23	A. Guyot, in Johnson's Universal Cyclopædia, Art. Earth, New York, 1876. [Mean of 4 values, 22° 15′, for 1827.2—SCH.]
	1827..	22 20	
	1828..	22 05	
	1829..	22 12	
34	1835.5.	22 04	Arago; Gen. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., vol. for 1872, part II; in $\phi = 48° 53′$, $\lambda = 2° 20′$ E.
35	1838, February.	21 38	Darondeau; Phil. Trans. Roy. Soc., 1849, part II.
36	1842.5.	21 29	Lamont; Gen. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., vol. for 1872, part II.
37	1858, January 1.	19 36.3	Rev. S. J. Perry; Magnetic survey of the east of France; Phil. Trans. Roy. Soc., vol. for 1872, London, 1873.
38	1865..	18 44	Encyclopædia Britannica, 9th edition, 1877, Art. Compass.
39	1869, September 1.	17 08.4	Rev. S. J. Perry; Magnetic survey of the east of France; reference as for No. 37.
40	1875, July.	17 21	Jordan's Vermessungskunde, Vol. 1, Stuttgart, 1877.
41	1879, January 1.	16 56	Annuaire pour l'an 1882, Paris.
42	1885, January 1.	16 10.2	Parc Saint Maur; Th. Moureaux, observer; Comptes Rendus de l'Académie, June, 1886; in $\phi = 48° 48′.6$, $\lambda = 2° 29′.6$ E. Annual change, 7′.4 losing. [For these values, and their reduction to Paris by the addition of the constant 4′.8, I am indebted to the courtesy of M. Moureaux, who communicated them in his letter of Feb. 1, 1887. The values, reduced to Paris, are therefore 16° 15′.0, 16° 08′.8, and 16° 02′.0, respectively—SCH.]
43	1886.0.	16 04.0	
44	1887.0.	15 57.2 W.	

* The values Nos. 1 to 30, inclusive, between 1541 and 1807, except for 1805, were taken from the article "Magnetism," by Peter Barlow, in the Encyclopædia of Experimental Philosophy (a part of the Ency. Metropolitana), London, 1848. [These values were combined by me into suitable groups, and their means were taken as indicated in the table—SCH.]

Collection of Magnetic Declinations, etc.—Continued.

42.—BERMUDA ISLANDS.

$\phi = 32^\circ\ 22'.6$ $\lambda = 64^\circ\ 42'.6$ W. of Gr.

(Signal station, St. George's Town.)

		° ′		
1	1831..	6 59	W.	Austin and Foster; Sir Edw. Sabine, in Phil. Trans. Roy. Soc., 1874, Cont'n xiv. In $\phi = 32^\circ\ 23'$, λ $64^\circ\ 47'$ W.
2	1837..	6 40		Milne; reference as before.
3	1845, October.	7 01		Capt. Barnett, Roy. Eng's; Bermuda Royal Gazette; at signal station; in $\phi = 32^\circ\ 23'$, $\lambda = 64^\circ\ 40'$ W.
4	1846..	6 53		Capt. Barnett, Roy. Eng's; Sir Edw. Sabine, in Phil. Trans. Roy. Soc., 1874, Cont'n xiv. In $\phi = 32^\circ\ 23'$, $\lambda = 64^\circ\ 47'$ W.
5	1873, May 13.	7 10		H. M. S. Challenger; Green outside dockyard, in $\phi = 32^\circ\ 19'.2$, $\lambda = 64^\circ\ 51'.8$ W. Results of the Voyage of H. M. S. Challenger; Narrative, vol. ii, London, 1882.
	1873, April 12.	7 15		H. M. S. Challenger; St. George, Button Island, in $\phi = 32^\circ\ 22'.6$, $\lambda = 64^\circ\ 42'.6$ W. Results of the Voyage of H. M. S. Challenger, Narrative, vol. ii, London, 1882, pp. 25 and 46. [According to Staff Commander E. W. Creak, R. N. ("On Local Magnetic Disturbance in Islands situated far from a Continent," Proceedings of the Royal Society, No. 242, 1886), the position on the Green outside dockyard appears to be the only one that may be taken as free from disturbing local attraction; I have therefore transcribed this and the result at St. George's, omitting the Challenger results at other stations on the Bermudas. Commander Creak assumes 2′ increase for the annual change about this time—SCH.]
6	1876..	7 45	W.	Brit. Admiralty Chart No. 360, Feb., 1877; annual increase of declination about 3′.

43.—RIO DE JANEIRO, BRAZIL.

$\phi = -22^\circ\ 54'.8$ $\lambda = 43^\circ\ 09'.5$ W. of Gr.*

(Flag-staff at Fort Villegagnon.)

		° ′		
1	1768..	7 34	E.	Cook } Voyages of the Adventure and Beagle, 1826–'36, Vol. 1, Capt. P. P. King, London, 1839, p. 523. Discussion by Major Sabine.
2	1787..	6 12		Hunter
3	1820..	2 54		Freycinet
4	1821..	3 21		Rumker
5	1830, May 23, 25, 26; June 2, 5, 13.	2 08.4		A. G. Erman, Reise um die Erde, etc., Berlin, 1835. In $\phi = -22'\ 53'.9$, $\lambda = 43^\circ\ 05'.2$ W.
6	1836..	2 00	E.	Capt. Fitz Roy; Voyages of the Adventure and Beagle, 1826–'36, London, 1839.
7	1857..	1 20	W.	Capt. E. O. Stanley and G. R. Richards and Lieut. Bullock, R. N.; Admiralty Chart No. 541. Fort Villegagnon, in $\phi = -22^\circ\ 54'.7$, $\lambda = 43^\circ\ 09'.0$ W.
8	1866, January 8.	2 41.8		W. Harkness, Prof. U. S. N.; position near north face of Fort Caraguata, in $\phi = -22^\circ\ 54'.1$, $\lambda = 43^\circ\ 06'.5$ W. Smithsonian Contributions to Knowledge No. 239, Washington, 1873, p. 61.
9	1876.5.	4 26	W.	Lieut. S. W. Very, U. S. N. From numerous observations at various times and different places. [MS. communication to me, dated Dec. 13, 1879—SCH.]

* Longitude from "telegraphic determinations of longitudes;" Lieut. Comdr's Green and Davis, U. S. N., 1878–'79, Washington, D. C., 1880.

Collection of Magnetic Declinations, etc.—Continued.

42.—RIO DE JANEIRO, BRAZIL—Continued.

10	1882, August 3.	° ′ 4 39 W.	Annales du Bureau des Longitudes, tome iii, Paris, 1883, p. 396–97. At this place the secular change is progressing perhaps at the most rapid rate known within the tropics and close to the magnetic equator. In a pamplet published in 1594, entitled "The Seaman's Secret," the celebrated navigator John Davis notes, under the head of remarks, after leaving Brazil, "the compass varies 9°, the *south* pointing *westward*." (Encycl. Brit., 9th edition, 1884, Art. Navigation)—Sch.

Results for Group I.—Magnetic stations on the eastern coast and within the region of the Appalachian range, inclusive of Newfoundland and some other foreign localities.

Geographical positions and expressions for the secular variation of the magnetic declination D (+West, —East). The letter m stands for t—1850.0 or for the difference in time, expressed in years and fraction of a year, for any time t and the middle of the century, and within the range of observation at any station.

No.	Name of station and State.	Latitude.	West longitude.	The magnetic declination expressed as a function of time.
		° ′	° ′	° ° °
1	Saint John's, Newfoundland.	47 34.4	52 41.9	$D=+20.58+10.60 \sin (1.4\ m+62.5)$
2	Charlottetown, Prince Edward Island.	46 14	63 27	$D=+15.95+7.78 \sin (1.2\ m+49.8)$
3	Halifax, Nova Scotia.	44 39.6	63 35.3	$D=+16.21+4.34 \sin (1.0\ m+47.2)$
4	Quebec, Canada.	46 48.4	71 14.5	$D=+14.66+3.03 \sin (1.4\ m+4.6)$ $+0.61 \sin (4.0\ m+0.3)$
5	Montreal, Canada.	45 30.5	73 34.6	$D=+11.88+4.17 \sin (1.5\ m-18.5)$ $+0.36 \sin (4.9\ m+19)$
6	Eastport, Me.	44 54.4	66 59.2	$D=+15.14+3.90 \sin (1.2\ m+31.7)$
7	Portland, Me.	43 38.8	70 16.6	$D=+11.26+3.16 \sin (1.33\ m+5.8)$
8	Burlington, Vt.	44 28.5	73 12.0	$D=+10.81+3.65 \sin (1.30\ m-20.5)$ $+0.18 \sin (7.0\ m+132)$
9	Hanover, N. H.	43 42.3	72 17.1	$D=+9.80+4.02 \sin (1.4\ m-14.1)$
10	Chesterfield, N. H.	42 53.5	72 24	$D=+9.60+3.84 \sin (1.35\ m-16.1)$*
11	Rutland, Vt.	43 36.5	72 55.5	$D=+10.03+3.82 \sin (1.5\ m-24.3)$
12	Portsmouth, N. H.	43 04.3	70 42.5	$D=+10.71+3.36 \sin (1.44\ m-7.4)$
13	Newburyport, Mass.	42 48.9	70 49.2	$D=+10.31+3.44 \sin (1.4\ m-4.6)$
14	Salem, Mass.	42 31.9	70 52.5	$D=+9.72+3.82 \sin (1.5\ m-0.7)$*
15	Boston, Mass.	42 21.5	71 03.9	$D=+9.48+2.94 \sin (1.3\ m+3.7)$
16	Cambridge, Mass.	42 22.9	71 07.7	$D=+9.54+2.69 \sin (1.30\ m+7.0)$ $+0.18 \sin (3.2\ m+44)$
17	Provincetown, Mass.	42 03.1	70 11.3	$D=+9.45+3.17 \sin (1.3\ m+12.8)$*
18	Nantucket, Mass.	41 17.0	70 06.0	$D=+8.61+2.83 \sin (1.35\ m+19.7)$
19	Providence, R. I.	41 50.2	71 23.8	$D=+9.10+2.99 \sin (1.45\ m-3.4)$ $+0.26 \sin (7\ m+84)$
20	Williamstown, Mass.	42 42.8	73 13.4	$D=+8.84+3.13 \sin (1.4\ m-14.0)$*
21	Hartford, Conn.	41 45.9	72 40.4	$D=+8.06+2.90 \sin (1.25\ m-26.4)$

* A rough expression.

Results for Group I—Continued.

No.	Name of station and State.	Latitude.	West longitude.	The magnetic declination expressed as a function of time.
		° ′	° ′	° ° °
22	New Haven, Conn.	41 18.5	72 55.7	$D=+7.78+3.11 \sin(1.40\,m-22.1)$
23	Albany, N. Y.	42 39.2	73 45.8	$D=+8.17+3.02 \sin(1.44\,m-8.3)$
24	Oxford, N. Y.	42 26.5	75 40.5	$D=+6.19+3.24 \sin(1.35\,m-18.9)$
25	New York City, N. Y.	40 42.7	74 00.4	$D=+6.61+2.40 \sin(1.54\,m-9.4)$
				$+0.14 \sin(6.3\,m+64)$
26	Bethlehem, Pa.	40 36.4	75 23.0	$D=+5.40+3.13 \sin(1.55\,m-38.3)$
27	Hatborough, Pa.	40 12	75 07	$D=+5.17+3.16 \sin(1.54\,m-16.7)$
				$+0.22 \sin(4.1\,m+157)$
28	Philadelphia, Pa.	39 56.9	75 09.0	$D=+5.36+3.17 \sin(1.50\,m-26.1)$
				$+0.19 \sin(4.0\,m+146)$
29	Harrisburg, Pa.	40 15.9	76 52.9	$D=+2.93+2.98 \sin(1.50\,m+0.2)$
30	Huntingdon, Pa.	40 31	78 02	$D=+2.50+2.71 \sin(1.5\,m-4.7)$*
31	Chambersburg, Pa.	39 55	77 40	$D=+2.79+3.10 \sin(1.55\,m-30.6)$
				$+0.15 \sin(4.6\,m+124)$
32	Baltimore, Md.	39 17.8	76 37.0	$D=+3.20+2.57 \sin(1.45\,m-21.2)$
33	Washington, D. C	38 53.3	77 00.6	$D=+2.49+2.45 \sin(1.45\,m-15.5)$
				$+0.14 \sin(10\,m+86)$
34	Cape Henlopen, Del.	38 46.7	75 05.0	$D=+3.72+2.88 \sin(1.4\,m-21.7)$
35	Williamsburg, Va.	37 16.2	76 42.4	$D=+2.33+2.56 \sin(1.5\,m-38.1)$
36	Cape Henry, Va.	36 55.6	76 00.4	$D=+2.48+2.22 \sin(1.5\,m-33.6)$
37	New Berne, N. C.	35 06	77 02	$D=+0.60+2.64 \sin(1.5\,m-15.4)$*
38	Charleston, S. C.	32 46.6	79 55.8	$D=-2.14+2.77 \sin(1.40\,m-3.1)$
39	Savannah, Ga.	32 04.9	81 05.5	$D=-2.92+2.23 \sin(1.4\,m-20.0)$*
40	Milledgeville, Ga.	33 04.2	83 12	$D=-3.14+2.45 \sin(1.5\,m-39.5)$*
41	Paris, France.	48 50.2	2 20.2 E.	$D=+6.479+16.002 \sin(0.765\,m+118°\,46'.5)$
				$+[0.85-0.35 \sin(0.69\,n)] \sin[(4.04+0.0054\,n$
				$+.000035\,n^2)\,n]$†
42	St. George's Town, Bermuda.	32 23	64 42	$D=+6.95+0.0145\,m+0.00056\,m^2$*
43	Rio de Janeiro, Brazil.	−22 54.8	43 09.5	$D=+2.19+9.91 \sin(0.80\,m-10.4)$*

* A rough expression.

† The secular variation observed at Paris is illustrated on accompanying plate No. 29. It is introduced for the purpose of showing the extremely systematic character of this variation. In the upper half of the diagram the dots indicate the observations, and the smooth curve represents the declination according to a constant and the first periodic term $D=+6°.479+16°.002 \sin(0.765\,m+118°\,46'.5)$. At this station the phenomenon has now been followed up for about 346 years, in which interval it exhibited two well marked extremes, viz, about the year 1581 a maximum eastern position, and about the year 1812 a maximum western position; the interval between these two consecutive elongations is 231 years, which may be regarded as the time of half a period; in the formula the numerical value of a implies 470 years for the period. The secondary wave superposed upon the primary is shown in the lower half of the diagram; it has two characteristics, viz, a variability in the parameter, that is a diminution in the size of the wave since about 1540, with a possible increase now, and secondly a variability in the length of the period, which was nearly constant in the second half of the sixteenth and throughout the seventeenth centuries, but afterwards diminished rapidly. Both variations, if real, are undoubtedly periodic, though from want of sufficient data our tabular expression is *limited* in time. It appeared to me doubtful whether one or two secondary waves lie between 1740 and 1870, and since the above diminution of the period hinges upon this question, two analytical expressions were presented in the last edition of this paper, one showing one crest, the other two crests within the interval. The latter expression is here given the preference in consequence of its better representing the latest observations. The factor (4.04, etc.) of n, where $n=t-1700$ corresponds to a length of period of about 90 years, which at present has diminished to about 57 years. These variations necessarily complicate the formula The law, however, may be studied at Paris to great advantage, and the station was only introduced here with the object of prominently showing the stately secular swing of the needle, and to facilitate the connection of its phases with those noted in North America.

GROUP I.—*Comparison of observed and computed Magnetic Declinations.*

SAINT JOHN'S, NEWFOUNDLAND.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
	°	°	°
1700.0	+15.00	+14.89	+ .11
1787.0	16.00	15.98	+ .02
1833.0	26.50	27.20	— .70
1844.8	29.60	29.28	+ .32
1857.5	31.35	30.71	+ .64
1862.7	31.33	31.03	+ .30
1863.7	31.30	31.07	+ .23
1864.4	31.00	31.10	— .10
1866.5	30.92	31.15	— .23
1881.6	+30.52	+30.73	— .21

CHARLOTTETOWN, PRINCE EDWARD ISLAND.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1833.0	+19.50	+19.76	— .26
1842.4	21.05	21.02	+ .03
1857.4	23.04	22.60	+ .44
1858.4	22.90	22.68	+ .22
1859.4	22.85	22.76	+ .09
1860.4	22.83	22.84	— .01
1861.4	22.75	22.91	— .16
1862.4	23.32	22.98	+ .34
1883.7	+23.43	+23.73	— .30

HALIFAX, NOVA SCOTIA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1608.0	+16.25	+17.32	—1.07
1700.0	13.00	11.98	+1.02
1756.5	12.83	13.07	— .24
1775.5	13.58	14.22	— .64
1798.5	16.50	15.88	+ .62
1818.5	17.47	17.39	+ .08
1821.6	17.60	17.61	— .01
1833.0	17.50	18.39	— .89
1852.7	18.77	19.53	— .76
1853.2	18.85	19.55	— .70
1860.5	19.92	19.88	+ .04
1866.3	21.09	20.09	+1.00
1873.4	21.58	20.30	+1.28
1879.7	+20.72	+20.44	+ .28

QUEBEC, CANADA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1642.5	+16.00	+17.00	—1.00
1686.5	+15.50	+17.33	—1.83

QUEBEC, CANADA—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
	°	°	°
1700.0	+16.00	+16.49	— .49
1785.5	12.58	12.24	+ .34
1789.5	11.75	12.22	— .47
1791.5	13.00	12.20	+ .80
1792.3	12.42	12.20	+ .22
1793.6	12.54	12.17	+ .37
1805.3	11.58	12.08	— .50
1810.5	11.62	12.08	— .46
1811.5	12.25	12.09	+ .16
1814.5	11.83	12.14	— .31
1820.8	12.54	12.33	+ .21
1821.7	12.90	12.36	+ .54
1822.2	13.00	12.39	+ .61
1823.6	13.00	12.45	+ .55
1824.2	12.67	12.49	+ .18
1831.7	13.40	12.99	+ .41
1832.4	13.00	13.05	— .05
1833.5	12.75	13.14	— .39
1834.4	13.31	13.22	+ .09
1835.9	13.17	13.36	— .19
1839.3	13.37	13.70	— .33
1840.5	13.71	13.81	— .10
1842.7	14.02	14.07	— .05
1846.5	14.53	14.49	+ .04
1847.7	14.64	14.63	+ .01
1848.5	14.58	14.72	— .14
1849.4	15.37	14.84	+ .53
1850.3	15.25	14.93	+ .32
1851.7	15.00	15.10	— .10
1853.1	15.50	15.26	+ .24
1858.8	15.57	15.89	— .32
1859.5	16.28	15.97	+ .31
1860.8	16.47	16.09	+ .38
1865.5	16.67	16.54	+ .13
1879.7	+17.23	+17.38	— .15

MONTREAL, CANADA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1749.5	+10.63	+10.76	— .13
1785.5	8.40	8.45	— .05
1793.6	8.25	8.16	+ .09
1814.5	7.75	7.77	— .02
1834.5	8.00	8.80	— .80
1835.5	+ 9.83	+ 8.90	+ .93

MONTREAL, CANADA—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
	°	°	°
1842.6	+ 8.97	+ 9.70	— .73
1859.5	12.35	11.90	+ .45
1879.7	+13.67	+13.79	— .12

EASTPORT, ME.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1608.0	+17.53	+18.96	—1.43
1700.0	13.00	13.09	— .09
1775.5	12.67	11.84	+ .83
1797.5	12.32	13.12	— .80
1833.0	14.50	15.90	—1.40
1860.8	17.95	17.88	+ .07
1861.5	17.99	17.92	+ .07
1862.5	18.01	17.98	+ .03
1863.5	18.04	18.03	+ .01
1864.3	18.06	18.08	— .02
1865.6	18.10	18.14	— .04
1873.7	18.93	18.52	+ .41
1879.7	+19.13	+18.74	+ .39

PORTLAND, ME.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1763.5	+ 7.75	+ 8.28	— .53
1775.5	8.50	8.11	+ .39
1845.4	11.47	11.24	+ .23
1851.6	11.69	11.69	.00
1859.5	12.33	12.26	+ .07
1863.5	12.47	12.54	— .07
1864.8	12.73	12.62	+ .11
1865.5	12.71	12.67	+ .04
1866.1	12.72	12.70	+ .02
1873.7	+12.89	+ 13.17	— .28

BURLINGTON, VT.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1793.5	+ 7.63	+ 7.35	+ .28
1805.5	6.20	7.22	—1.02
1818.5	7.50	7.43	+ .07
1822.5	7.70	7.62	+ .08
1826.5	7.60	7.88	— .28
1830.5	8.17	8.18	— .01
1831.5	8.25	8.26	— .01
1832.5	+ 8.42	+ 8.34	+ .08

Group I.—*Comparison of observed and computed Magnetic Declinations*—Continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O − C.
BURLINGTON, VT.—continued.			
	°	°	°
1834.5	+ 8.83	+ 8.50	+ .33
1837.5	8.75	8.75	.00
1845.5	9.37	9.37	.00
1855.7	9.95	10.01	− .06
1873.8	+11.32	+11.31	+ .01
HANOVER, N. H.			
1765.5	+ 7.00	+ 6.83	+ .17
1810.5	4.25	6.04	−1.79
1839.5	9.25	7.87	+1.38
1873.7	10.83	11.11	− .28
1879.8	+11.64	+11.66	− .02
CHESTERFIELD, N. H.			
1812.5	+ 6.43	+ 6.07	+ .36
1813.5	6.42	6.11	+ .31
1814.5	6.28	6.15	+ .13
1815.5	6.12	6.19	− .07
1816.5	6.05	6.23	− .18
1817.5	6.04	6.27	− .23
1818.5	6.00	6.32	− .32
1819.5	6.05	6.37	− .32
1820.5	6.00	6.42	− .42
1821.5	6.12	6.47	− .35
1822.5	6.20	6.52	− .32
1823.5	6.50	6.58	− .08
1824.5	6.67	6.64	+ .03
1825.5	6.58	6.70	− .12
1826.5	6.58	6.76	− .18
1827.5	6.75	6.82	− .07
1828.5	6.87	6.88	− .01
1829.5	7.00	6.94	+ .06
1830.5	7.10	7.01	+ .09
1831.5	7.17	7.08	+ .09
1832.5	7.25	7.15	+ .10
1833.5	7.50	7.22	+ .28
1834.5	7.58	7.29	+ .29
1835.5	7.67	7.36	+ .31
1836.5	7.75	7.44	+ .31
1837.5	8.09	7.52	+ .57
1874.7	+10.44	+10.74	− .30
RUTLAND, VT.			
	°	°	°
1789.3	+ 7.05	6.58	+ .47
1810.4	6.07	6.23	− .16
1811.7	6.02	6.25	− .23
1859.6	9.82	9.37	+ .45
1873.8	10.67	10.79	− .12
1879.8	+11.15	+11.36	− .21
PORTSMOUTH, N. H.			
1771.5	+ 7.77	+ 7.81	− .04
1775.5	7.75	7.66	+ .09
1833.0	8.75	8.94	− .19
1845.0	9.78	9.86	− .08
1850.7	10.50	10.33	+ .17
1859.5	11.25	11.08	+ .17
1879.6	+12.52	+12.65	− .13
NEWBURYPORT, MASS.			
1775.5	+ 6.75	+ 7.06	− .31
1781.5	7.30	6.93	+ .37
1833.0	8.50	8.67	− .17
1850.7	10.09	10.10	− .01
1859.5	+10.97	+10.83	+ .14
SALEM, MASS.			
1781.6	+ 6.90	+ 6.00	+ .90
1805.8	5.95	6.21	− .26
1808.5	5.33	6.32	− .99
1810.8	5.94	6.43	− .49
1833.0	8.50	8.03	+ .47
1849.6	10.24	9.63	+ .61
1855.6	10.83	10.23	+ .60
1877.5	+11.50	+12.20	− .70
BOSTON, MASS.			
1700.0	+10.00	+10.06	− .06
1708.5	9.00	9.49	− .49
1741.5	7.50	7.49	+ .01
1776.0	+ 7.67	+ 6.54	+1.13
BOSTON, MASS.—continued.			
	°	°	°
1782.5	+ 7.00	+ 6.55	+ .45
1793.5	6.50	6.72	− .22
1807.5	6.08	7.18	−1.10
1833.0	8.00	8.55	− .55
1839.5	9.10	8.97	+ .13
1846.7	9.52	9.45	+ .07
1855.6	10.23	10.04	+ .19
1872.8	11.25	11.09	+ .16
1877.5	+11.60	+11.35	+ .25
CAMBRIDGE, MASS.			
1708.5	+ 9.00	+ 9.26	− .26
1742.5	8.00	7.66	+ .34
1757.5	7.33	7.24	+ .09
1761.5	7.23	7.13	+ .10
1763.5	7.00	7.09	− .09
1780.5	7.03	6.86	+ .17
1782.5	6.75	6.85	− .10
1783.5	6.87	6.86	+ .01
1788.5	6.63	6.89	− .26
1810.5	7.50	7.48	+ .02
1835.5	8.85	8.98	− .13
1837.5	9.15	9.11	+ .04
1840.4	9.30	9.32	− .02
1842.2	9.57	9.45	+ .12
1844.5	9.65	9.61	+ .04
1845.4	9.53	9.68	− .15
1850.6	9.50	10.03	− .53
1852.5	10.13	10.16	− .03
1854.5	10.21	10.29	− .08
1855.4	10.91	10.35	+ .56
1856.5	10.47	10.42	+ .05
1859.2	10.80	10.59	+ .21
1867.5	10.70	11.05	− .35
1879.6	+11.77	+11.58	+ .19
PROVINCETOWN, MASS.			
1609.5	+12.00	+12.20	− .20
1700.0	9.50	9.57	− .07
1776.5	6.50	6.31	+ .19
1833.0	+ 8.25	+ 8.94	− .69

GROUP I.—*Comparison of observed and computed Magnetic Declinations*—**Continued.**

PROVINCETOWN, MASS.—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
	°	°	°
1835.7	+ 9.33	+ 9.13	+ .20
1860.7	+11.39	+10.87	+ .52

NANTUCKET, MASS.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1700.0	+ 8.25	+ 8.75	— .50
1775.5	6.50	5.82	+ .68
1833.0	7.50	8.45	— .95
1834.5	8.45	8.55	— .10
1839.0	9.04	8.85	+ .19
1842.7	9.15	9.09	+ .06
1843.7	9.17	9.16	+ .01
1846.6	9.23	9.35	— .12
1855.6	9.97	9.91	+ .06
1867.4	10.33	10.55	— .22
1879.6	11.46	11.05	+ .41
1883.4	+11.43	+11.17	+ .26

PROVIDENCE, R. I.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1717.5	+ 9.60	+ 9.68	— .08
1769.5	6.50	6.28	+ .22
1815.5	6.50	6.60	— .10
1819.5	6.62	6.69	— .07
1835.5	7.57	7.79	— .22
1840.5	8.42	8.30	+ .12
1841.5	8.52	8.40	+ .12
1842.5	8.65	8.50	+ .15
1843.5	8.77	8.60	+ .17
1855.6	9.52	9.56	— .04
1884.5	11.13	11.13	.00
1885.3	+11.16	+11.19	— .03

WILLIAMSTOWN, MASS.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1786.5	+ 5.87	+ 5.79	+ .08
1833.5	6.25	6.95	— .70
1837.5	7.75	7.21	+ .54
1876.6	10.52	10.07	+ .45
1886.6	+10.35	+10.73	— .38

HARTFORD, CONN.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1786.5	+ 5.42	+ 5.28	+ .14
1810.5	+ 4.77	+ 5.25	— .48

HARTFORD, CONN.—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
	°	°	°
1824.5	+ 5.75	+ 5.60	+ .15
1829.0	6.05	5.76	+ .29
1859.6	7.29	7.34	— .05
1867.6	7.82	7.84	— .02
1879.6	+ 8.57	+ 8.59	— .02

NEW HAVEN, CONN.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1761.5	+ 5.78	+ 6.04	— .26
1775.5	5.42	5.28	+ .14
1780.5	5.25	5.07	+ .18
1811.5	5.17	4.76	+ .41
1819.8	4.42	4.97	— .55
1828.5	5.28	5.32	— .04
1835.3	5.68	5.67	+ .01
1836.5	5.92	5.74	+ .18
1837.9	5.83	5.82	+ .01
1840.5	6.17	5.98	+ .19
1844.6	5.75	6.24	— .49
1845.7	6.29	6.32	— .03
1848.6	6.58	6.51	+ .07
1855.6	7.05	7.01	+ .04
1872.5	8.46	8.29	+ .17
1878.5	8.69	8.73	— .04
1884.5	8.93	9.15	— .22
1885.2	+ 9.00	+ 9.20	— .20

ALBANY, N. Y.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1817.8	+ 5.73	+ 5.71	+ .02
1818.6	5.75	5.74	+ .01
1825.3	6.00	6.08	— .08
1828.6	6.27	6.26	+ .01
1830.5	6.30	6.38	— .08
1831.6	6.54	6.45	+ .09
1834.8	6.67	6.65	+ .02
1836.8	6.78	6.78	.00
1847.9	7.58	7.58	.00
1855.7	7.91	8.17	— .26
1856.7	8.58	8.24	+ .34
1858.4	8.28	8.37	— .09
1879.6	+ 9.86	+ 9.87	— .01

OXFORD, N. Y.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
	°	°	°
1794.0	+ 3.00	+ 2.96	+ .04
1817.5	3.00	3.31	— .31
1828.5	4.50	3.79	+ .71
1834.8	3.87	4.13	— .26
1836.8	4.15	4.26	— .11
1837.5	4.50	4.30	+ .20
1838.5	4.45	4.36	+ .09
1849.9	5.18	5.14	+ .04
1857.3	5.73	5.68	+ .05
1858.1	5.78	5.74	+ .04
1859.0	5.83	5.81	+ .02
1873.9	6.87	6.94	— .07
1874.4	6.93	6.97	— .04
1885.7	+ 7.72	+ 7.77	— .05

NEW YORK, N. Y.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1609.7	+ 8.00	+ 5.79	+2.21
1684.5	8.75	9.14	— .39
1686.5	9.00	9.11	— .11
1691.5	8.75	8.99	— .24
1700.0	8.33	8.65	— .32
1714.5	8.75	7.96	+ .79
1724.0	7.33	7.55	— .22
1750.5	6.37	5.94	+ .43
1755.5	5.00	5.57	— .57
1789.5	4.33	4.37	— .04
1824.5	4.67	4.67	.00
1834.5	4.83	5.21	— .38
1837.5	5.67	5.42	+ .25
1840.6	5.45	5.65	— .20
1841.5	6.10	5.71	+ .39
1842.6	5.91	5.80	+ .11
1844.6	6.22	5.95	+ .27
1845.6	6.42	6.02	+ .40
1846.3	5.57	6.08	— .51
1847.8	5.68	6.19	— .51
1855.6	6.72	6.72	.00
1860.7	6.73	7.01	— .28
1873.8	7.48	7.63	— .15
1874.6	7.38	7.66	— .28
1879.5	7.87	7.89	— .02
1885.7	+ 8.21	+ 8.19	+ .02

Group I.—*Comparison of observed and computed Magnetic Declinations*—Continued.

BETHLEHEM, PA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1757.5	+ 6.50	+ 5.49	+ 1.01
1784.5	2.88	3.38	— .50
1799.5	1.87	2.60	— .73
1841.6	3.43	2.96	+ .47
1851.5	3.83	3.56	+ .27
1874.5	5.32	5.38	— .06
1878.2	5.62	5.69	— .07
1881.2	5.87	5.95	— .08
1882.7	6.08	6.07	+ .01
1884.0	+ 6.10	+ 6.18	— .08

HATBOROUGH, PA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1680.5	+ 8.47	+ 8.31	+ .16
1690.5	8.25	8.16	+ .09
1700.5	7.92	7.86	+ .06
1710.5	7.47	7.45	+ .02
1720.5	7.00	6.96	+ .04
1730.5	6.42	6.38	+ .04
1740.5	5.58	5.66	— .08
1750.5	4.92	4.83	+ .09
1760.5	4.00	3.93	+ .07
1770.5	2.92	3.07	— .15
1780.5	2.08	2.38	— .30
1790.5	1.83	1.95	— .12
1800.5	1.92	1.84	+ .08
1810.5	2.00	2.05	— .05
1820.5	2.45	2.50	— .05
1830.5	3.00	3.08	— .08
1840.5	3.83	3.73	+ .10
1850.5	+ 4.42	+ 4.39	+ .03

PHILADELPHIA, PA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1701.5	+ 8.50	+ 8.13	+ .37
1710.5	8.50	7.81	+ .69
1750.5	5.75	5.28	+ .47
1793.5	1.50	2.22	— .72
1802.5	1.50	2.14	— .64
1804.5	2.08	2.09	— .01
1813.5	2.43	2.23	+ .20
1837.5	3.87	3.31	+ .56
1840.5	+ 3.62	+ 3.49	+ .13

PHILADELPHIA, PA.—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1841.7	+ 3.90	+ 3.57	+ .33
1846.4	3.85	3.85	.00
1855.7	4.53	4.45	+ .08
1862.6	5.00	4.90	+ .10
1872.8	5.46	5.64	— .18
1877.7	6.04	6.03	+ .01
1884.7	+ 6.36	+ 6.57	— .21

HARRISBURG, PA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1795.6	— 0.43	— 0.02	— .41
1840.5	+ 3.21	+ 2.21	+ 1.00
1843.5	2.58	2.44	+ .14
1854.8	3.01	3.31	— .30
1857.4	3.32	3.51	— .19
1861.0	3.50	3.79	— .29
1862.6	3.74	3.90	— .16
1874.8	4.85	4.74	+ .11
1876.9	5.17	4.86	+ .31
1877.7	4.89	4.91	— .02
1885.6	+ 5.36	+ 5.33	+ .03

HUNTINGDON, PA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1840.6	+ 1.87	+ 1.63	+ .24
1852.3	2.27	2.46	— .19
1874.6	3.57	3.94	— .37
1880.7	4.25	4.29	— .04
1881.5	4.39	4.33	+ .06
1883.3	4.56	4.43	+ .13
1884.4	4.62	4.48	+ .14
1886.0	+ 4.63	+ 4.55	+ .08

CHAMBERSBURG, PA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1736.8	+ 4.25	+ 4.06	+ .19
1744.7	3.67	3.53	+ .14
1746.2	3.32	3.43	— .11
1754.5	3.27	2.82	+ .45
1768.6	1.50	1.71	— .21
1770.3	1.50	1.58	— .08
1786.2	+ 0.25	0.37	— .12
1787.2	— 0.25	+ 0.30	— .55

CHAMBERSBURG, PA.—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
	°	°	°
1794.5	— 0.50	— 0.09	— .41
1808.5	0.71	0.44	- .27
1816.9	0.50	0.36	-- .14
1818.4	0.37	0.31	— .06
1822.9	— 0.25	0.17	— .08
1825.9	0.00	— 0.05	+ .05
1830.8	+ 0.25	+ 0.19	+ .06
1836.2	0.45	0.48	— .03
1840.6	0.99	0.74	+ .25
1850.3	1.50	1.35	+ .15
1852.3	1.70	1.48	+ .22
1859.8	2.20	2.00	+ .20
1863.2	2.25	2.23	+ .02
1864.2	2.32	2.31	+ .01
1865.4	2.40	2.39	+ .01
1866.1	2.42	2.45	— .03
1867.8	2.58	2.56	+ .02
1869.4	2.67	2.68	— .01
1871.4	2.92	2.83	+ .09
1873.3	3.00	2.97	+ .03
1876.5	3.21	3.21	.00
1877.4	3.33	3.29	+ .04
1878.3	3.35	3.36	— .01
1879.3	3.47	3.43	+ .04
1880.3	3.53	3.52	+ .01
1881.3	3.60	3.59	+ .01
1882.3	3.72	3.68	+ .04
1883.6	3.78	3.77	+ .01
1884.3	3.82	3.83	— .01
1885.4	3.88	3.92	— .04
1886.4	3.88	4.00	— .12
1887.1	+ 4.00	+ 4.05	— .05

BALTIMORE, MD.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
1679.0	+ 5.25	+ 5.77	— .52
1683.5	6.25	5.75	+ .50
1703.5	5.12	5.27	— .15
1720.5	4.21	4.45	— .24
1729.2	4.02	3.93	+ .09
1754.5	2.28	2.31	— .03
1756.9	2.88	2.16	+ .72
1771.0	+ 1.11	+ 1.41	— .30

Group I.—*Comparison of observed and computed Magnetic Declinations*—**Continued.**

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
BALTIMORE, MD.—continued.			
	°	°	°
1776.1	+ 1.75	+ 1.19	+ .56
1780.5	0.77	1.02	— .25
1787.5	0.37	0.82	— .45
1808.5	0.21	0.66	— .45
1840.7	2.27	1.76	+ .51
1847.3	2.31	2.11	+ .20
1856.7	2.49	2.69	— .20
1875.5	3.74	3.90	— .16
1877.8	4.18	4.04	+ .14
1885.6	+ 4.49	+ 4.50	— .01
WASHINGTON, D. C.			
1792.5	— 0.24	— 0.04	— .20
1809.9	+ 0.87	+ 0.24	+ .63
1841.0	1.34	1.31	+ .03
1842.0	1.40	1.40	.00
1855.5	2.40	2.26	+ .14
1856.6	2.36	2.30	+ .06
1857.2	2.41	2.32	+ .09
1860.7	2.44	2.46	— .02
1862.7	2.66	2.53	+ .13
1863.6	2.70	2.57	+ .13
1866.8	2.74	2.73	+ .01
1867.5	2.80	2.77	+ .03
1868.5	2.85	2.83	+ .02
1869.3	2.88	2.88	.00
1870.5	2.89	2.96	— .07
1871.5	2.95	3.03	— .08
1872.5	3.00	3.11	— .11
1873.5	3.00	3.18	— .18
1874.5	3.11	3.27	— .16
1875.5	3.26	3.35	— .09
1876.3	3.31	3.41	— .10
1877*.5	3.66	3.50	+ .16
1878.6	3.75	3.59	+ .16
1879.4	3.84	3.65	+ .19
1880.3	3.92	3.71	+ .21
1882.5	3.93	3.86	+ .07
1883.5	4.00	3.95	+ .05
1884.3	+ 4.03	+ 4.00	+ .03
WASHINGTON, D. C.—continued.			
	°	°	°
1885.5	+ 4.19	+ 4.07	+ .12
1886.5	+ 4.15	+ 4.12	+ .03
CAPE HENLOPEN, DEL.			
1609.7	+ 7.50	+ 5.76	+1.74
1700.0	6.00	5.98	+ .02
1795.5	0.92	0.87	+ .05
1833.0	1.25	1.67	— .42
1843.8	2.43	2.26	+ .17
1846.5	2.75	2.43	+ .32
1856.6	3.07	3.10	— .03
1885.6	+ 4.99	+ 5.08	— .09
WILLIAMSBURG, VA.			
1694.5	+ 5.00	+ 4.89	+ .11
1780.5	+ 0.83	+ 0.76	+ .07
1809.5	— 0.55	— 0.20	— .35
1840.0	+ 0.75	+ 0.28	+ .47
1874.9	+ 2.20	+ 2.30	— .10
CAPE HENRY, VA.			
1700.0	+ 4.00	+ 4.66	— .66
1728.2	3.33	3.79	— .46
1732.5	4.53	3.58	+ .95
1809.5	0.00	0.27	— .27
1832.4	0.75	0.56	+ .19
1856.7	1.47	1.59	— .12
1874.9	2.66	2.63	+ .03
1879.4	2.70	2.88	— .18
1881.4	3.27	3.00	+ .27
1883.5	3.37	3.11	+ .26
1884.5	+ 3.18	+ 3.17	+ .01
NEW BERNE, N. C.			
1796.5	— 2.67	— 2.03	— .64
1806.5	2.00	2.01	+ .01
1809.5	— 1.75	— 1.96	+ .21
NEW BERNE, N. C.—continued.			
	°	°	°
1840.0	0.00	— 0.74	+ .74
1875.0	+ 1.34	+ 1.59	— .25
CHARLESTON, S. C.			
1700.0	— 0.50	— 0.63	+ .13
1775.5	3.80	4.78	+ .98
1784.1	5.25	4.90	— .35
1785.8	5.75	4.91	— .84
1825.0	3.75	3.85	+ .10
1833.0	4.00	3.39	— .61
1837.5	2.90	3.12	+ .22
1840.5	2.73	2.92	+ .19
1841.4	2.40	2.86	+ .46
1847.8	2.25	2.44	+ .19
1849.3	2.28	2.34	+ .06
1874.4	0.97	0.71	— .26
1880.1	0.43	0.40	— .03
1886.0	— 0.24	— 0.10	— .14
SAVANNAH, GA.			
1817.5	— 4.00	— 4.95	+ .95
1833.0	5.00	4.46	— .54
1838.5	5.08	4.23	— .85
1839.5	3.52	4.19	+ .67
1852.3	3.67	3.56	— .11
1857.3	3.46	3.30	— .16
1874.2	2.28	2.38	+ .10
1886.0	— 1.62	— 1.79	+ .17
MILLEDGEVILLE, GA.			
1805.5	— 5.50	— 5.49	— .01
1835.5	4.67	5.29	+ .62
1838.5	5.85	5.19	— .66
1875.5	— 3.06	— 3.20	+ .14
PARIS, FRANCE.			
1541.5	— 7.00	— 6.60	— .40
1550.5	— 8.00	— 7.50	— .50

* Change of station between 1876 and 1877.

GROUP I.—*Comparison of observed and computed Magnetic Declinations*—Continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
PARIS, FRANCE—continued.			
	°	°	°
1580.5	—11.50	—10.73	— .77
1603.5	8.75	8.76	+ .01
1610.5	8.00	7.64	— .36
1630.5	4.50	4.51	+ .01
1642.5	2.50	3.08	+ .58
1660.0	1.50	1.11	— .39
1664.5	— 0.67	0.47	— .20
1667.0	+ 0.13	— 0.08	+ .21
1670.5	1.50	+ 0.51	+ .99
1682.5	3.13	3.03	+ .10
1687.5	4.87	4.25	+ .62
1695.1	6.62	6.27	+ .35
1703.5	9.00	8.54	+ .46
1712.5	11.18	10.86	+ .32
1721.5	12.87	12.84	+ .03
1730.5	14.62	14.40	+ .22
1739.5	15.38	15.61	— .23
1748.5	16.62	16.66	— .04
1757.1	17.82	17.69	+ .13
1765.6	19.00	18.92	+ .08
1772.5	+20.02	+20.01	+ .01
PARIS, FRANCE—continued.			
	°	°	°
1779.5	+20.67	+21.09	— .42
1784.5	21.42	21.75	— .33
1791.5	22.30	22.39	— .09
1800.0	22.23	22.64	— .41
1803.5	21.97	22.59	— .62
1805.5	22.08	22.53	— .45
1807.5	22.57	22.45	+ .12
1812.2	22.33	22.21	+ .12
1816.5	22.37	22.02	+ .35
1827.2	22.25	21.80	+ .45
1835.5	22.07	21.84	+ .23
1838.2	21.63	21.82	— .19
1842.5	21.48	21.66	— .18
1858.0	19.60	19.51	+ .09
1865.5	18.73	18.10	+ .63
1869.7	17.14	17.52	— .38
1875.5	17.35	16.94	+ .41
1879.0	16.93	16.71	+ .22
1885.0	16.25	16.08	+ .17
1886.0	16.15	15.93	+ .22
1887.0	+16.03	+15.76	+ .27
ST. GEORGE'S TOWN, BERMUDA.			
	°	°	°
1831.5	+ 6.98	+ 6.88	+ .10
1837.5	6.67	6.85	— .18
1845.8	7.02	6.90	+ .12
1846.5	6.88	6.91	— .03
1873.3	7.21	7.60	— .39
1876.5	+ 7.75	+ 7.73	+ .02
RIO DE JANEIRO, BRAZIL.			
1768.5	— 7.57	— 7.41	— .16
1787.5	6.20	6.42	+ .22
1820.5	2.90	3.35	+ .45
1821.5	3.35	3.24	— .11
1830.5	2.14	2.15	+ .01
1836.5	— 2.00	— 1.40	— .60
1857.5	+ 1.33	+ 1.43	— .10
1866.0	2.70	2.61	+ .09
1876.5	4.43	4.05	+ .38
1882.6	+ 4.65	+ 4.88	— .23

RESULTS FOR GROUP I.—Continued.

Contents of columns: Year of first observation and whole number of observations used in the discussion; probable error of an observation or of a representation; year of nearest easterly digression or magnetic elongation with corresponding amount of minimum *west* declination (or maximum *east* declination); annual change for three modern epochs. *West* declination is indicated by a *plus* sign as is also *increasing west* declination; the contrary direction is indicated by a minus sign.

Number.	Station.	Year of first observation.	Number of observations.	Probable error of an observation.	Nearest epoch of eastern elongation.	Minimum (west) declination at epoch.	Nearest epoch of western elongation.	Maximum (west) declination at epoch.	Annual change in— 1885.0.	1890.0.	1895.0.
				′		°		°	′	′	′
1	Saint John's, Newfoundland.	1833	10	±18	1741	+10.0	1870	+31.2	—5.7	—7.4	—9.0
2	Charlottetown, Prince Edward Island.	1833	9	12	1734	+ 8.2	1884	+23.7	—0.3	—1.4	—2.4
3	Halifax, Nova Scotia.	1608	14	32	1713	+11.9	1893(?)	+20.4	+0.6	+0.2	—0.2
4	Quebec, Canada.	1642	37	20	1807	+12.1	1889(?)	+17.5	+0.7	0.0	—0.9
5	Montreal, Canada.	1749	9	31	1814	+ 7.7	----	----	+3.6	+3.3	+3.4
6	Eastport, Me.	1608	13	29	1749	+11.2	1899(?)	+19.0	+1.3	+0.9	+0.3
7	Portland, Me.	1763	10	10	1778	+ 8.1	1913(?)	+14.4	+2.7	+2.3	+1.8
8	Burlington, Vt.	1793	13	13	1810	+ 7.2	----	----	+5.8	+5.0	+3.8
9	Hanover, N. H.	1765	5	±27	1796	+ 5.8	----	----	+4.8	+4.4	+3.9

RESULTS FOR GROUP I.—Continued.

Number.	Station.	Year of first observation.	Number of observations.	Probable error of an observation.	Nearest epoch of eastern elongation.	Minimum (west) declination at epoch.	Nearest epoch of western elongation.	Maximum declination at epoch.	Annual change in— 1885.0.	1890.0.	1895.0.
				′		°		°	′	′	′
10	Chesterfield, N. H.	1812	27	±16	1795	+ 5.8	---	---	+4.6	+4.3	+3.9
11	Rutland, Vt.	1789	6	16	1806	+ 6.2	---	---	+5.3	+4.9	+4.4
12	Portsmouth, N. H.	1771	7	7	1793	+ 7.3	---	---	+3.7	+3.2	+2.7
13	Newburyport, Mass	1775	5	13	1789	+ 6.9	---	---	+3.6	+3.1	+2.6
14	Salem, Mass.	1781	8	31	1790	+ 5.9	---	---	+3.7	+3.1	+2.4
15	Boston, Mass.	1700	13	23	1778	+ 6.5	---	---	+2.6	+2.2	+1.9
16	Cambridge, Mass.	1708	24	11	1783	+ 6.9	---	---	+1.8	+1.5	+1.2
17	Provincetown, Mass.	1609	6	19	1771	+ 6.3	1909(?)	+12.6	+2.3	+1.8	+1.4
18	Nantucket, Mass.	1700	12	19	1769	+ 5.8	1902(?)	+11.4	+1.6	+1.1	+0.6
19	Providence, R. I.	1717	12	7	1779	+ 6.0	---	---	+4.7	+4.4	+3.6
20	Williamstown, Mass.	1786	5	31	1796	+ 5.7	---	---	+3.8	+3.4	+3.0
21	Hartford, Conn.	1786	7	12	1799	+ 5.2	---	---	+3.6	+3.5	+3.3
22	New Haven, Conn.	1761	18	11	1802	+ 4.7	---	---	+4.1	+3.8	+3.4
23	Albany, N. Y.	1817	13	6	1793	+ 5.2	---	---	+3.4	+3.0	+2.5
24	Oxford, N. Y.	1794	14	9	1797	+ 3.0	---	---	+4.0	+3.7	+3.4
25	New York City, N. Y.	1609	26	18	1799	+ 4.3	---	---	+2.8	+2.9	+2.8
26	Bethlehem, Pa.	1757	10	19	1817	+ 2.3	---	---	+4.9	+4.6	+4.3
27	Hatborough, Pa.	1680	18(?)	6	1797	+ 1.8	---	---	+5.2	+4.4	+3.3
28	Philadelphia, Pa.	1701	16	17	1802	+ 2.1	---	---	+4.7	+4.4	+4.4
29	Harrisburg, Pa.	1795	11	15	1790	0.0	---	---	+2.8	+2.3	+1.8
30	Huntingdon, Pa.	1840	8	10	1793	---	---	— 0.2	+2.9	+2.4	+1.9
31	Chambersburg, Pa.	1736	40	7	1809	---	---	— 0.4	+4.8	+4.7	+4.5
32	Baltimore, Md.	1679	18	17	1802	+ 0.6	---	---	+3.4	+3.1	+2.8
33	Washington, D. C.	1792	30	6	1798	---	---	— 0.3	+3.4	+1.9	+1.0
34	Cape Henlopen, Del.	1609	8	12	1801	+ 0.8	---	---	+3.8	+3.5	+3.2
35	Williamsburg, Va.	1694	5	17	1815	---	---	— 0.2	+3.9	+3.7	+3.5
36	Cape Henry, Va.	1700	11	19	1812	+ 0.3	---	---	+3.3	+3.1	+2.9
37	New Berne, N. C.	1796	5	25	1800	---	---	— 2.0	+3.3	+3.0	+2.5
38	Charleston, S. C.	1700	14	19	1788	---	---	— 4.9	+2.8	+2.4	+2.0
39	Savannah, Ga.	1817	8	26	1800	---	---	— 5.2	+2.9	+2.6	+2.4
40	Milledgeville, Ga.	1805	4	26	1816	---	---	— 5.6	+3.7	+3.6	+3.4
					At eastern elongation. Epoch.	Amount.	At western elongation. Epoch.	Amount.			
						°		°			
41	Paris, France.*	1541	44	17	1581	—10.7	1799	+22.6	—8.8†	---	---
42	Saint George's Town, Bermuda.	1831	6	11	1838	+ 6.8	---	---	+3.4	+3.6	+3.8
43	Rio de Janeiro, Brazil.	1768	10	±14	---	---	---	---	+7.9	+7.7	+7.5

*The maximum west declination, according to the formula, was reached in 1799, but according to direct observation in 1807 and again in 1814; the latter value, however, would certainly place it too late, the observation referring to noon and to a single day. The observations when plotted appear stunted about the time of turn in the secular motion; omitting the effect of the secondary wave the primary wave would place the maximum in the year 1812.

†According to Mr. Moureaux's observations (Mémoires divers; observations magnétioues faites à l'observatoire du Parc Saint-Maur, pendant l'année, 1885) the decrease between 1884.5 and 1885.5 was 6′.3.

RESULTS FOR GROUP I.—Completed.

Ephemeris of magnetic declinations. Computed magnetic declination at each station for every tenth year of the series, and after 1850 for every fifth year. A plus sign signifies westerly declination, a minus sign easterly declination. The *first* tabular result for any station indicates that the first observation made there falls between that tabular date and the next one following it.

Year (January 1).	Saint John's, Newfoundland.	Charlottetown, Prince Edward Island.	Halifax, Nova Scotia.	Quebec, Canada.	Montreal, Canada.	Eastport, Me.	Portland, Me.	Burlington, Vt.	Hanover, N. H.	Chesterfield, N.H.	Rutland, Vt.	Portsmouth, N. H.
	°	°	°	°	°	°	°	°	°	°	°	°
1600	----	----	+18*	----	----	+19*						
10			+17			+19						
20			----			----						
30			----			----						
40			----	+17		----						
1650	----	----	----	+17	----	----						
60			----	----		----						
70			----	----		----						
80			----	17.5		----						
90	+17		+12.2	+17.2		+13.8						
1700	+15	----	+12.0	+16.5	----	+13.1						
10	+13		11.9	15.5		12.5						
20	----		11.9	----		11.9						
30	----		12.1	----		11.5						
40	----		+12.4	----	+12.0	+11.3						
1750	----	----	+12.8	----	+10.7	+11.2	----	----	----	----	----	----
60	----		13.3	----	9.7	11.3	+ 8.4		+ 7.2			
70	----		13.9	----	9.0	11.6	8.2		6.6			+ 7.9
80	+14		14.5	+12.2	8.6	12.1	8.1		6.1		+ 7.1	7.5
90	+17		+15.2	+12.2	+ 8.3	+12.6	+ 8.2	+ 7.4	+ 5.8		+ 6.6	+ 7.4
1800	----	----	+16.0	+12.1	+ 8.0	+13.3	+ 8.5	+ 7.3	+ 5.8	----	+ 6.3	+ 7.4
10	----		16.8	12.1	7.8	14.1	8.9	7.2	6.0	+ 6.0	6.23	7.7
20	----		17.5	12.3	7.9	14.9	9.5	7.49	6.5	6.4	6.46	8.1
30	+26.6	+19.3	18.2	12.9	8.4	15.7	10.1	8.14	7.2	7.0	6.93	8.72
40	+28.5	+20.7	+18.8	+13.8	+ 9.4	+16.5	+10.85	+ 8.95	+ 7.9	+ 7.7	+ 7.61	+ 9.47
1850	+30.0	+21.9	+19.3	+14.9	+10.7	+17.2	+11.58	+ 9.66	+ 8.82	+ 8.5	+ 8.46	+10.28
55	30.5	22.4	19.6	15.5	11.4	17.52	11.94	9.96	9.31	9.0	8.93	10.70
60	30.9	22.8	19.9	16.0	12.0	17.83	12.29	10.26	9.80	9.4	9.41	11.12
65	31.1	23.2	20.1	16.5	12.5	18.12	12.63	10.60	10.28	9.9	9.91	11.53
70	+31.2	+23.4	+20.2	+16.9	+13.0	+18.36	+12.95	+10.98	+10.76	+10.3	+10.41	+11.94
1875	+31.1	+23.6	+20.3	+17.2	+13.5	+18.58	+13.25	+11.42	+11.24	+10.8	+10.90	+12.32
80	30.8	23.7	20.4	17.4	13.8	18.74	13.52	11.91	11.68	11.2	11.38	12.68
85	30.4	23.7	20.5	17.5	14.1	18.88	13.76	12.41	12.1	11.6	11.84	13.00
90	29.9	23.7	20.6	17.5	14.4	19.0	14.0	12.85	12.5	12.0	12.26	13.3
95	+29.2	+23.5	+20.6	+17.5	+14.7	+19.0	+14.1	+13.2	+12.8	+12.3	+12.6	+13.5

*Results for seventeenth century very doubtful.

RESULTS OF GROUP I.—Completed.

Year (January 1).	Newburyport, Mass.	Salem, Mass.	Boston, Mass.	Cambridge, Mass.	Provincetown, Mass.	Nantucket, Mass.	Providence, R. I.	Williamstown, Mass.	Hartford, Conn.	New Haven, Conn.	Albany, N. Y.	Oxford, N. Y.
	°	°	°	°	°	°	°	°	°	°	°	°
1600	----	----	----	----	+12*							
10					12							
20					12.5							
30					13							
40					+12.5							
1650	----	----	----	----	+12							
60					12							
70					11.5							
80					11							
90					+10							
1700	----	----	+10.1	+9.8	+9.5	+9	----					
10			9.4	9.2	9	8	+10.4					
20			8.7	8.7	8	7.5	9.5					
30			8.1	8.2	7.5	7	8.8					
40			+7.6	+7.82	+7	+6.5	+8.4					
1750	----	----	+7.1	+7.46	+6.6	+6	+7.8	----	----	----	----	----
60			6.8	7.17	6.4	6	7.0			+6.1		
70	+7.2		6.6	6.96	6.3	5.8	6.3			5.6		
80	7.0	+6.1	6.5	6.86	6.4	5.9	6.0	+5.9	+5.4	5.1		
90	+6.9	+5.9	+6.65	+6.90	+6.6	+6.1	+6.2	+5.7	+5.2	+4.8		+3.01
1800	+7.0	+6.0	+6.90	+7.10	+7.0	+6.5	+6.46	+5.7	+5.16	+4.7	----	+2.96
10	7.3	6.4	+7.29	7.46	7.5	7.0	6.54	5.9	5.24	4.7	+5.41	3.10
20	7.8	7.0	7.78	7.97	8.1	7.6	6.71	6.3	5.46	5.0	5.81	3.40
30	8.5	7.8	8.37	8.60	8.73	8.25	7.29	6.8	5.80	5.39	6.35	3.87
40	+9.2	+8.7	+9.01	+9.29	+9.44	+8.92	+8.24	+7.4	+6.24	+5.95	+7.00	+4.46
1850	+10.04	+9.67	+9.67	+9.99	+10.15	+9.56	+9.18	+8.1	+6.77	+6.61	+7.74	+5.14
55	10.45	10.17	10.00	10.33	10.50	9.87	9.53	8.5	7.06	6.97	8.12	5.51
60	10.87	10.66	10.33	10.63	10.83	10.16	9.78	8.8	7.36	7.35	8.49	5.89
65	11.28	11.14	10.64	10.92	11.14	10.42	10.00	9.2	7.68	7.72	8.86	6.26
70	+11.67	+11.59	+10.94	+11.17	+11.4	+10.67	+10.21	+9.6	+7.99	+8.10	+9.23	+6.65
1875	+12.05	+12.01	+11.22	+11.40	+11.7	+10.89	+10.47	+10.0	+8.30	+8.47	+9.57	+7.02
80	12.4	12.39	11.47	11.59	11.9	11.07	10.79	10.3	8.62	8.84	9.90	7.38
85	12.7	12.7	11.7	11.74	12.1	11.21	11.17	10.6	8.92	9.19	10.19	7.72
90	13.0	13.0	11.9	11.9	12.3	11.33	11.56	10.9	9.2	9.52	10.46	8.05
95	+13.2	+13.2	+12.1	+12.0	+12.5	+11.4	+11.9	+11.2	+9.5	+9.8	+10.7	+8.35

*Results for seventeenth century very doubtful.

RESULTS OF GROUP I.—Completed.

Year (January 1).	New York City, N.Y.	Bethlehem, Pa.	Hatborough, Pa.	Philadelphia, Pa.	Harrisburg, Pa.	Huntingdon, Pa.	Chambersburg, Pa.	Baltimore, Md.	Washington, D.C.	Cape Henlopen, Del.
	°	°	°	°	°	°	°	°	°	°
1600	+5*	----	----	----	----	----	----	----	----	+3*
10	6									4
20	6.5									4.5
30	7									5
40	+7.5									+5.5
1650	+8	----	----	----	----	----	----	----	----	+6
60	8.5									6.5
70	8.9							+5.7		6.6
80	9.1		+8.3					5.8		6.5
90	+9.0		+8.2					+5.7		+6.4
1700	+8.7	----	+7.9	+8.2	----	----	----	+5.4	----	+6.0
10	8.2		7.5	7.8				5.0		5.5
20	7.7		7.0	7.4				4.5		4.9
30	7.3		6.4	6.8			+4.50	3.9		4.2
40	+6.7		+5.7	+6.2			+3.85	+3.2		+3.5
1750	+6.0	+6.1	+4.8	+5.3	----	----	+3.16	+2.6	----	+2.8
60	5.3	5.3	3.9	4.4			2.40	2.0		2.2
70	4.7	4.5	3.1	3.6			1.60	1.46		1.6
80	4.4	3.7	2.4	2.8			0.81	1.04		1.2
90	+4.4	+3.1	+2.0	+2.3	−0.1		+0.14	+0.76	+0.0	+0.9
1800	+4.3	+2.6	+1.8	+2.1	+0.0	----	−0.30	+0.64	−0.1	+0.8
10	4.4	2.3	2.0	2.16	0.3		−0.44	0.68	+0.2	0.9
20	4.52	2.3	2.5	2.44	0.8		−0.27	0.88	0.5	1.1
30	4.92	2.5	3.0	2.91	1.4		+0.14	1.23	0.65	1.5
40	+5.60	+2.9	+3.7	+3.46	+2.2	+1.6	+0.70	+1.70	+1.25	+2.04
1850	+6.35	+3.46	+4.35	+4.07	+2.94	+2.3	+1.34	+2.27	+1.98	+2.65
55	6.68	3.81	4.6	4.39	3.33	2.6	1.67	2.58	2.24	2.99
60	6.97	4.19	5.0	4.73	3.71	3.0	2.01	2.90	2.44	3.33
65	7.23	4.58	5.3	5.08	4.08	3.3	2.36	3.23	2.64	3.68
70	+7.47	+5.00	+5.7	+5.44	+4.43	+3.66	+2.72	+3.55	+2.93	+4.03
1875	+7.69	+5.42	+6.2	+5.81	+4.75	+3.97	+3.10	+3.87	+3.30	+4.38
80	7.92	5.85	6.7	6.20	5.05	4.25	3.49	4.17	3.70	4.72
85	8.15	6.26	7.1	6.59	5.30	4.51	3.89	4.47	4.04	5.04
90	8.41	6.66	7.6	6.97	5.52	4.7	4.29	4.74	4.26	5.34
95	+8.7	+7.03	+7.9	+7.4	+5.7	+4.9	+4.67	+5.00	+4.37	+5.6

* Results for the seventeenth century very doubtful.

Results of Group I.—Completed.

Year (January 1).	Williamsburg, Va.	Cape Henry, Va.	New Berne, N. C.	Charleston, S. C.	Savannah, Ga.	Milledgeville, Ga.	Paris, France.	St. George's Town, Bermuda Islands.	Rio de Janeiro, Brazil.
	°	°	°	°	°	°	°		
1540	--------	--------	--------	--------	------	------	− 6.5		
1550	--------	--------	--------	--------	------	------	− 7.4		
60							8.8		
70							10.0		
80							10.6		
90							−10.4		
1600	--------	--------	--------	--------	------	------	− 9.3		
10							7.7		
20							6.1		
30							4.6		
40							− 3.3		
1650	--------	--------	--------	--------	------	------	− 2.3		
60							− 1.1		
70							+ 0.4		
80							+ 2.5		
90	+4.9						+ 4.9		
1700	+4.9	+4.6	--------	−0.6	------	------	+ 7.6		
10	4.7	4.5		1.2			10.3		
20	4.4	4.1		1.9			12.6		
30	3.9	3.7		2.6			14.3		
40	+3.3	+3.1		−3.2			+15.7		
1750	+2.7	+2.6	--------	−3.8	------	------	+16.8	------	------
60	2.0	2.0		4.3			18.1		−7.63
70	1.4	1.5		4.7			19.6		7.35
80	0.8	1.0		4.86			21.2		6.89
90	+0.3	+0.6	−2	−4.91			+22.3		−6.25
1800	−0.0	+0.4	−2	−4.79	------	−5.4	+22.6	------	−5.44
10	—0.2	0.26	2	4.52	−5.1	5.6	22.3		4.49
20	—0.2	0.30	1.7	4.10	4.9	5.6	21.9		3.43
30	−0.1	0.45	1.3	3.57	4.6	5.4	21.8	+6.9	2.22
40	+0.3	+0.82	−0.7	−2.95	−4.17	−5.1	+21.8	+6.86	−0.94
1850	+0.75	+1.25	−0.1	−2.29	−3.68	−4.7	+20.9	+6.95	+0.40
55	1.03	1.51	+0.2	1.95	3.42	4.4	20.1	7.02	1.08
60	1.33	1.77	+0.6	1.62	3.15	4.2	19.1	7.15	1.77
65	1.65	2.05	+0.9	1.29	2.88	3.9	18.2	7.30	2.46
70	+1.97	+2.34	+1.3	−0.97	−2.61	−3.5	+17.5	+7.46	+3.15
1875	+2.30	+2.63	+1.6	−0.68	−2.34	−3.2	+17.0	+7.66	+3.84
80	2.64	2.92	1.9	−0.40	2.08	2.9	16.6	7.89	4.51
85	2.97	3.20	2.2	−0.15	1.84	2.6	16.1	8.14	5.18
90	3.3	3.47	2.5	+0.07	1.61	2.3	15.1	8.4	5.83
95	+3.6	+3.7	+2.7	+0.3	−1.4	−2.0	+13.8	+8.7	+6.5

GROUP II.—*Series of Magnetic Stations mainly in the central part of the United States between the Appalachian and Rocky Mountain ranges.*

The stations of this central series are distributed over the region south of the Hudson Bay and the area between the eastern and western mountain ranges inclosing the drainage of the Gulf of Mexico, with two stations in the West Indies and one in Central America.

Observations were collected and discussed for secular change of declination at the following places:

1. York Factory, Hudson Bay, Br. Poss.
-- Michipicoten, Ontario, Canada.
2. Sault de Ste. Marie, Mich.
3. Duluth, Minn., and Superior City, Wis.
4. Pierrepont Manor, N. Y.
5. Toronto, Canada.
6. Grand Haven, Mich.
-- Madison, Wis.
-- Milwaukee, Wis.
7. Buffalo, N. Y.
8. Detroit, Mich.
9. Erie, Pa.
10. Chicago, Ill.
11. Cleveland, Ohio.
12. Omaha, Nebr.
13. Pittsburgh, Pa.
-- Denver, Colo.
14. Marietta, Ohio.
15. Cincinnati, Ohio.
16. Saint Louis, Mo.
-- Nashville, Tenn.
17. Florence, Ala.
-- Natchez, Miss.
18. Mobile, Ala.
19. New Orleans, La.
20. San Antonio, Tex.
21. Key West, Fla.
22. Havana, Cuba.
23. Kingston, Port Royal, Jamaica.
24. Panama, New Granada.

The first column of the record for any station contains the running number of the observed values made use of in the discussion, the second the date of the observation, the third the observed value, and the fourth the name of the observer, the geographical position of the station, the reference to publication, and other pertinent remarks.

1.—YORK FACTORY, HUDSON BAY.

$\phi = 56° 59'.9$ $\lambda = 92° 26'$ W. of Gr.

		° ′	
1	1725..	19 W.	Capt. Middleton; Hansteen's Magnetismus der Erde, 1819.
2	1787..	5 W.	Hansteen's isogonic chart; reference as above.
3	1819, September.	6 00.3 E.	Sir John Franklin, in $\phi = 57° 00'$, $\lambda = 92° 26'$ W. Gen. Sir Edw. Sabine, Proc. Roy. Soc., 1858, and Conts. to Terr. Mag. No. xiii, Phil. Trans. Roy. Soc., 1872.
4	1843, July 24, 26.	9 00.6	Capt. Lefroy, R. E.; Sir J. H. Lefroy's Magnetic Survey of Canada, etc., London, 1883.
5	1857, August.	7 37	Capt. Blakiston, R. E.; reference as before.
	1878..	5 30	Alfred R. C. Selwyn, director Geological Survey of Canada; Report of 1878–'79, appendix vii, Montreal, 1880. At N. E. side of fort; this locality appeared to be subject to local attraction. [Value not used—SCH.]
6	1879..	7 00	Observer and reference as before; at the S. W. side of fort.
7	1884, September 12, 13.	6 39.8 E.	Otto J. Klotz, D. T. S. Communicated by the Hon. E. Deville, Dept. of the Int., Ottawa. At Capt. Lefroy's station, in $\phi = 56° 59'.9$, $\lambda = 92° 26'$ W. See also letter of O. J. Klotz to this office, dated March 19, 1885.

GROUP II.—*Series of Magnetic Stations, etc.*—Continued.

MICHIPICOTEN, ONTARIO, CANADA.

$\phi = 47° 56'.0$ $\lambda = 84° 50'.6$ W. of Gr.

(Garden, Hudson Bay Company's ground.)

		° ′		
1	1824..	4 33	E.	Capt. Bayfield, R. N.; Sir Edw. Sabine, in Phil. Trans. Roy. Soc., 1872, Cont'n xiii. Fort Michipicoten is placed in $\phi = 47° 56'$, $\lambda = 85° 05'$ W.
2	1844, October 30.	0 20.3	E.	Lieut. J. H. Lefroy, R. E.; Gen. Sir J. H. Lefroy's Diary of Magnetic Survey of Canada, etc., London, 1883, p. 167; in $\phi = 47° 56'.0$, $\lambda = 84° 54'$ W. [In foot-note, p. 72, it is pointed out that the value heretofore given (3° 49′ E.) was erroneous—SCH.]
3	1880, July 21, September 9.	1 20.5	W.	Lieut. S. W. Very, U. S. N., Actg. Asst. Coast and Geodetic Survey. Position as in heading. Coast and Geodetic Survey Report for 1881, App. 9. [Results at this station insufficient for discussion; the corrected value for 1844 appears less probable than the old value—SCH.]

2.—SAULT DE STE. MARIE, MICH.

$\phi = 46° 29'.9$ $\lambda = 84° 20'.1$ W. of Gr.

(Garden of Fort Brady.)

		° ′		
1	1790..	0	E.	Alex. Mackenzie; Voyages through the continent of America, London, 1801. Falls of Ste. Marie, in $\phi = 46° 31'$, $\lambda = 84° 00'$ W.
	1819, May 2.	2 32.8		Sir John Franklin; Sir J. H. Lefroy's Magnetic Survey of Canada, etc., London, 1883. [Not used—SCH.]
2	1843..	1 08		Lieut. J. H. Lefroy; Sir Edw. Sabine in Phil. Trans. Roy. Soc., Cont'n xiii, 1872.
3	1844, November 4.	1 01.1		Lieut. J. H. Lefroy; Sir J. H. Lefroy's Magnetic Survey of Canada, etc., London, 1883. In Phil. Trans. Roy. Soc., 1872, position in $\phi = 46° 31'$, $\lambda = 84° 32'$ W.
4	1845..	0 46		Observer, position, and reference as before.
5	1846, November.	0 40		Lieut. G. C. Westcott, U. S. A. Information from Mr. J. B. Baylor.
6	1856, September 29.	0 32.1	E.	Karl Friesach; Kais. Acad. der Wiss., vol. 29, Vienna, 1858; position assigned $\phi = 46° 30'$, $\lambda = 84° 34'$ W.
7	1873, July 22, 23.	0 04.9	W.	Capt. A. N. Lee, U. S. E.; Survey of the N. and N. W. Lakes, Gen. C. B. Comstock in charge. MS. of 1873, also Report of Chief of Engineers, U. S. A., 1874, App. C C. In $\phi = 46° 30'$, $\lambda = 84° 20'.0$ W.
8	1879, November 12.	1 01.0		City Surveyor at Fort Brady. Information from Mr. J. B. Baylor.
9	1880, July 11, 13, 14, 17, 19.	0 53.7		Lieut. S. W. Very, U. S. N.; Actg. Asst. Coast and Geodetic Survey. In vegetable garden of Fort Brady; in $\phi = 46° 29'.9$, $\lambda = 84° 20'.1$ W. Coast and Geodetic Survey Report for 1881, App. 9.
	1880, August 6, 7.	1 04.5	W.	J. B. Baylor, U. S. Coast and Geodetic Survey. In military post garden, about 30 meters N. W. of Lieut. Very's position of 1880. Reference as above. [Mean 0° 59′.1 W.—SCH.]

GROUP II.—*Series of Magnetic Stations, etc.*—Continued.

3.—DULUTH, MINN., AND SUPERIOR CITY, WIS.

$\phi = 46° 45'.5$, $\lambda = 92° 04'.5$ W. of Gr. $\phi = 46° 39'.9$, $\lambda = 92° 04'.2$ W. of Gr.

		° ′	
	1824.5.	12 30 E.	Capt. Bayfield, at river St. Louis, near Fond du Lac, in $\phi = 46° 43'$, $\lambda = 92° 10'$ W. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., 1872, Cont'n xiii. [To reduce to Duluth subtract 10′; not used—SCH.]
1	1859, July.	9 25.2	Lieut. W. P. Smith, U. S. Survey of N. and N.W. Lakes; Capt. G. G. Meade, Detroit, 1859. At Minnesota Point, in $\phi = 46° 46'$, $\lambda = 92° 14'$ W.
2	1861..	10 12	U. S. Survey of N. and N.W. Lakes.
3	1870, September 20.	10 30	Gen. C. B. Comstock, U. S. Lake Survey; at Superior City, in $\phi = 46° 43'$, $\lambda = 92° 04'$ W. Gen. Comstock's letter of May 7, 1875.
4	1871, June 20, 27.	10 40	Gen. C. B. Comstock; reference as before. In $\phi = 46° 45'.4$, $\lambda = 92° 04'.5$ W. At North Base, Minnesota Point.
	1873, August 13, 15.	11 51.8	Capt. A. N. Lee, U. S. E.; at Duluth; Report of Chief of Engineers, 1874, App. C C, and letter of Gen. Comstock as above. In $\phi = 46° 45'.5$, $\lambda = 92° 04'.5$ W. [Not used.—SCH.]
5	1880, August 21, 23.	9 45.4 E.	J. B. Baylor, U. S. Coast and Geodetic Survey; at Superior City, in $\phi = 46° 40'$, $\lambda = 92° 04'$ W. Coast and Geodetic Survey Report for 1881, App. 9. [To this value double weight is given—SCH.]

4.—PIERREPONT MANOR, JEFFERSON COUNTY, N. Y.

$\phi = 43° 44'.5$ $\lambda = 76° 03'.0$ W. of Gr.*

		° ′	
1	1823, September 18.	2 16.1 W.	W. C. Pierrepont. Letter of Verplanck Colvin of May 5, 1871; also, report of the Adirondack State-land survey, 1886, Verplanck Colvin superintendent, Albany, 1886. [Compared with an observation at Lowville in 1821, viz, 4° 30′ W., the Pierrepont Manor value appears too small. A table of values in the Adirondack Survey Reports for 1884 and 1886, giving observed and interpolated declinations between 1797 and 1874, is very defective.† The weight ½ is assigned to the 1823 observation—SCH.]
2	1847, September 18.	4 23	Letter of V. Colvin of May 5, 1871, and his reports of Adirondack Surveys of 1884, 1886.
3	1856, November 25.	5 10.0	
4	1860, July 15, 16.	5 36	
5	1863, July 10.	5 44	
6	1864, April 12.	5 50	
7	1865, {May / June} 4.	6 00	
8	1866, September 11.	6 15	
9	1867, July 27.	6 10	
10	1868, May 12.	6 10	
11	1869, May 11.	6 18	
12	1870, May 27, September 21.	6 03.5 W.	

* The geographical position here given depends on that of Mannsville as determined by the U. S. Lake Survey.

† The table gives zero declination for October 1, 1797. This mistake originally arose, I supppose, by confusing the annual change, which was then about zero, with the declination itself. Mr. Colvin himself points out elsewhere in his report of 1886 that the declination was *not* zero in the Adirondack region about that time, but reprints the table uncorrected.

GROUP II.—*Series of Magnetic Stations, etc.*—Continued.

4.—PIERREPONT MANOR, JEFFERSON COUNTY, N. Y.—Continued.

		° ′	
13	1874..	6 44 W.	Letter of V. Colvin of May 5, 1871, and his reports of Adirondack Surveys of 1884, 1886.
	1874, October 20.	6 11.9 W.	Dr. T. C. Hilgard, Observer to U. S. Coast Survey. Station half a mile S.W. of village, stone in pasture on Pierrepont's meridian line. [Weighted value 6° 33′ W. adopted—SCH.]

5.—TORONTO, ONTARIO, CANADA.

$\phi=43° 39'.4$ $\lambda=79° 23'.5$ W. of Gr.

(The Magnetic Observatory.*)

		° ′	
1	1840, January.	1 27 W.	Capt. C. J. B. Riddell, R. A. Phil. Trans. Roy. Soc., 1849.
2	1841.5.	1 14.3	Vol. i, Toronto Mag'l and Met'l Observations, p. xi. Mean annual declinations. In the abstract of results, published in 1875, 1° 19′.1 W. is given for 1842.5.
3	1842.5.	1 18.9	
4	1845.5.	1 29.1	Vol. ii, Toronto Mag'l and Met'l Observations, pp. iii–v. Mean annual declinations.
5	1846.5.	1 30.8	
6	1847.5.	1 33.2	
7	1848.5.	1 35.4	
8	1849.5.	1 36.9	
9	1850.5.	1 38.6	
10	1851.5.	1 40.9	
11	1853, July and August.	1 46.1	These values are corrected for annual and secular variations.
12	1854, February, March, April, and June.	1 48.0	
13	1855, August to December, both inclusive.	1 52.3	
14	1856.5.	1 56.3	Mean annual declinations.
15	1857.5.	2 00.5	
16	1858.5.	2 04.5	
17	1859.5.†	2 07.4	
18	1860.5.	2 10.6	
19	1861.5.	2 14.3	
20	1862.5.	2 15.7	
21	1863.5.	2 19.1	
22	1864.5.	2 21.9	
23	1865.5.	2 24.8	
24	1866.5.	2 27.6	
25	1867.5.	2 29.8	
26	1868.5.	2 33.2 W.	

* For values in the above table prior to 1869, see also results published by G. T. Kingston, M. A., director of the Magnetic Observatory, Toronto, in the Canadian Journal, especially two communications, "Monthly absolute values of the magnetic elements at Toronto, from 1856 to 1864, inclusive," and "Monthly absolute values of the magnetic elements at Toronto, from 1865 to 1868, inclusive, with the annual means from 1841 to 1868." Director Kingston placed the observatory in $\phi=43° 39'.4$, $\lambda=79° 23'.3$ W.

† June 25–30, 1859, Lieut. W. P. Smith observed the declination 2° 11′.6 W. Capt. G. G. Meade, U. S. Survey of the N. and N.W. Lakes, Detroit, 1859. [Not used—SCH.]

GROUP II.—*Series of Magnetic Stations, etc.*—Continued.

5.—TORONTO, ONTARIO, CANADA—Continued.

		° ′	
27	1869.5.	2 37.1 W.	Abstracts and Results of magnetical and meteorological observations at the Magnetic Observatory, Toronto, Canada, from 1841 to 1871, inclusive. Toronto, 1875. Mean annual declinations.
28	1870.5.	2 41.9	
29	1871.5.	2 47.9	
30	1872.5.	2 53.0	Mean annual declinations communicated Feb. 28, 1881, by Mr. Chas. Carpmael, director of the Toronto Magnetic Observatory and Supt. of the Meteorological Service, Toronto, Ontario. [In a recent communication to the Supt. of the Naut. Alm. he gives the longitude 79° 23′ 39″—SCH.]
31	1873.5.	2 58.3	
32	1874.5.	3 04.1	
33	1875.5.	3 11.7	
34	1876.5.	3 18.5	
35	1877.5.	3 24.9	
36	1878.5.	3 31.4	
37	1879.5.	3 37.3	
38	1880, October 18.	3 41.1	Communicated by Mr. C. Carpmael, director of the observatory, Jan. 14, 1881.
39	1884, August.	3 57.2 W.	Communicated by Mr. Otto J. Klotz. Proceedings of the Association of Dominion Land Surveyors, Ottawa, 1885.

6.—GRAND HAVEN, MICH.

$\phi=43° 05'.2$ $\lambda=86° 12'.6$ W. of Gr.

		°	
1	1825..	3½ to 6° E.	L. Lyon; at Grand River in $\phi=42° 55'$, $\lambda=86° 10'$ W. Prof. E. Loomis, Sill. Jour., vol. xxxix, 1840.
		° ′	
2	1837..	4 30	Geological Report; reference as above. In $\phi=42° 55'$, $\lambda=86° 10'$ W.
		6 15	Geological Report; reference as above. In $\phi=43° 19'$, $\lambda=85° 59'$ W.
3	1859, August 18.	4 24.2	Lieut. W. P. Smith, U. S. Survey of N. and N. W. Lakes; report by Capt. G. G. Meade, Detroit, 1859. In $\phi=43° 05'.2$, $\lambda=86° 12'.6$ W.
4	1865..	4 15	U. S. Survey of N. and N. W. Lakes. MS. by Col. Reynolds, Dec., 1865. In $\phi=43° 04'$, $\lambda=86° 13'$ W.
5	1873, August 28, 29.	3 28.2	Capt. A. N. Lee, U. S. Survey of N. and N. W. Lakes; MS. of 1873. See also Report of Chief of Engineers for 1874.
6	1880, July 20, 21.	2 25.7 E.	J. B. Baylor, U. S. Coast and Geodetic Survey. In grounds of the county court-house, $\phi=43° 04'.7$, $\lambda=86° 12'.6$ W. Coast and Geodetic Survey Report for 1881, App. 9.

MADISON, WIS.

$\phi=43° 04'.6$ $\lambda=89° 24'.2$ W. of Gr.

(University of Wisconsin.)

		° ′	
1	1839, November 2.	7 30 E.	Dr. J. Locke; in survey of "Mineral Lands," Exec. Doc., 1839–40, vol. vi, 1839. In $\phi=43° 03'$, $\lambda=89° 11'$ W.
2	1841, September.	7 30 E.	Dr. Locke and Prof. Loomis; southeast of the State-house (or capitol), in $\phi=43° 04'.5$, $\lambda=89° 23'.0$ W. Phil. Trans. Roy. Soc., 1872. [The long. given, 89° 06′, is much in error—SCH.]

GROUP II.—*Series of Magnetic Stations, etc.*—Continued.

MADISON, WIS.—Continued.

		° ′		
	1876, October 10, 11, 12, 13, 14.	6 59.7 E.	F. E. Hilgard, observer for U. S. Coast Survey; Coast and Geod'c Survey Rep. for 1881, App. 9. [Not used—SCH.]	Station near and south of University central building, in $\phi=43°$ 04′.5, $\lambda=89°$ 24′.2 W. [This place was found affected by the erection of a water tank and of vertical pipes, hence a new station was established in 1878 on the University farm,* about 1 st. mile west—SCH.]
	1877, August 30, September 21.	6 44.9	A. Braid, U. S. Coast Survey. Reference as above. [Not used—SCH.]	
3	1878, August 29, 30.	6 34.0	Dr. Gustavus Hinrichs; in connection with magnetic survey of Iowa. MS. communcation.	
	1878, September 8, 9, 10, 11, 12, 13.	6 31.8	W. Suess, observer for U. S. Coast Survey; Coast and Geodetic Survey Report for 1881, App. 9.	
	1878, November 22, 23, 25.	6 22.9	J. B. Baylor, U. S. Coast and Geod'c Survey. Reference as before. [Corrected for local attraction; weight assigned, ½—SCH.]	
4	1879, September 22 to October 11.	6 26.8	David Mason, observer for Coast and Geod'c Survey. Station on University Hill, south of building.	
5	1880, September 15 to 22.	6 20.9 E.	Observer, position, and reference as above.	

* The observations on the University farm, in $\phi=43°$ 04′.5, $\tau=89°$ 25′.2 W., gave the following results (see Coast and Geod'c Survey Report for 1881, App. 9):

	° ′			° ′
1878, November 13, 14, 15.	6 31.7 E.	J. B. Baylor, observer.	[Combining the two stations, the following mean values were adopted:	For 1878.8, 6 31.3 E.
1879, October 6, 7, 8, 9.	6 30.9	Dav. Mason, observer.		1879.7, 6 28.8
1880, September 23 to 28.	6 22.9	Dav. Mason, observer.		1880.7, 6 21.9
1881, December 16, 17, 18, 19.	6 21.0 E.	W. Suess, observer.		1881.9, 6 19.8 E. —SCH.]

[From the values collected at this station nothing further can be deduced than the average annual change, which was +3′.9 between 1878 and 1882—SCH.]

MILWAUKEE, WIS.

$\phi=43°$ 03′ $\lambda=87°$ 56′ W. of Gr.

		° ′	
1	1859, August 20.	6 20.1 E.	Lieut. W. P. Smith, U. S. Survey of N. and N. W. Lakes; communicated by Capt. G. G. Meade, Detroit, 1859. In $\phi=43°$ 02′.8, $\lambda=87°$ 55′.1 W.
2	1873, August 22.	6 22.4	Capt. A. N. Lee, U. S. E.; survey of N. and N. W. Lakes, Gen'l C. B. Comstock in charge. MS. received in 1873. Position as above.
3	1878, May.	6 43 E.	Major D. C. Houston, U. S. E.; Report of Chief of Engineers, 1878, part ii, p. 1166, map. [Observations insufficient for discussion—SCH.]

GROUP II.—*Series of Magnetic Stations, etc.*—Continued.

7.—BUFFALO, N. Y.

$\phi=42° 52'.8$ $\lambda=78° 53'.5$ W. of Gr.

(Light-house in the harbor.)

		° ′	
1	1797..	0 00 W.	Amry Atwater, surveyor; east end of Lake Erie. MS. collection by Charles Whittlesey; communicated to the Coast Survey March 26, 1860.
2	1798..	0 30	Buffalo reservation, lake shore. August Porter, in twenty-second report of Regents of University, New York, Albany, 1869.
3	1837..	1 25	R. W. Haskins, in $\phi=42° 53'$, $\lambda=78° 55'$ W. Prof. E. Loomis' collection, Sill. Jour., vol. xxxiv, 1838.
4	1839..	1 15	At Fort Erie, $\phi=42° 52'$, $\lambda=78° 59'$ W. U. S. Lake Survey chart.
5	1845..	1 25	Capt. J. H. Lefroy; Gen. Sir Edw. Sabine's Contribution xiii, in Phil. Trans. Roy. Soc., 1872.
6	1859, June.	2 56.5	Lieut. W. P. Smith; U. S. Lake Survey, in $\phi=42° 53'$, $\lambda=78° 53'$ W., near south pier. Report of the U. S. Lake Survey, by Capt. G. G. Meade, Detroit, 1859, App. B.
7	1872, June 14.	3 52.4	Capt. A. N. Lee, U. S. Lake Survey, in $\phi=42° 53'$, $\lambda=78° 54'$ W. Report of Chief of Engineers for 1873, magnetic results, 1870–73, pp. 1195–1197.
8	1873, June 4 and 5.	3 58.3	Observer, position, and reference as before.
9	1885, September 17, 18, 19.	5 04.3 W.	J. B. Baylor, subasst. U. S. Coast and Geodetic Survey. At Fort Porter, $\phi=42° 55'$, $\lambda=78° 54'$ W. MS. in Coast and Geodetic Survey archives.

8.—DETROIT, MICH.

$\phi=42° 20'.0$ $\lambda=83° 03'.0$ W. of Gr.

		° ′	
1	1810..	2 48 E.	J. Mansfield. Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838. Position assigned, $\phi=42° 30'$, $\lambda=82° 58'$ W.
2	1822..	3 13	L. Lyons } Prof. E. Loomis' collection in Sill. Jour., vol. xxxix, 1840. Position assigned, $\phi=42° 24'$, $\lambda=82° 58'$ W.
3	1828..	2 50	L. Lyons }
4	1835..	2 10	Geological Report }
5	1840..	2 00	Geological Report }
	1840..	1 56	Prof. E. Loomis; Gen. Sir Edw. Sabine, Phil. Trans. Roy. Soc., 1872, Contribution No. xiii.
6	1859, April.	0 42	U. S. Lake Survey. MS. communicated by Col. W. F. Raynolds, U. S. E. Position assigned, $\phi=42° 20'$, $\lambda=83° 03'$ W.
7	1865..	0 40	
8	1872, May 8–29.	0 25.2	Capt. A. N. Lee, U. S. A., observer; U. S. Lake Survey, Gen. C. B. Comstock Superintendent. Report of the Chief of Engineers for 1873, pp. 1195–1197. Position assigned, $\phi=42° 20'.0$, $\lambda=83° 02'.5$ W.
9	1873, May 5–17.	0 17.3	
10	1876, June 3, 6.	0 04.7 E.	Lieut. T. N. Bailey, observer; U. S. Lake Survey; Report of Chief of Engineers for 1877, vol. 2. Position assigned, $\phi=42° 20'$, $\lambda=83° 03'.1$ W.
11	1885, September 2, 3, 4.	0 31.0 W.	J. B. Baylor, subasst. U. S. Coast and Geodetic Survey. MS. in C. and G. S. archives. Rear of Harper Hospital. In $\phi=42° 21'.0$, $\lambda=83° 03'.1$ W.

Group II.—*Series of Magnetic Stations, etc.*—Continued.

9.—ERIE, PA.

$\phi = 42° 07'.8$ $\lambda = 80° 05'.4$ W. of Gr.

(Court-house.)

		° ′		
1	1786, October.	0 32	W.	New York and Pennsylvania boundary line; monument on French Creek, in $\phi = 42° 00'$, $\lambda = 79° 58'$ W., about 10 miles S.S.E. of Erie. Geological Survey of New York. See also map in the State Dept. of New York on which the observed variations are "protracted by Abm. Hardenberg, one of the Commissioners for the State of New York, Oct. 29, 1787."
2	1793--	0 42.2	E.	Annual report of the Secretary for Internal Affairs, State of Pa., 1885; Harrisburg, 1886.
3	1795--	0 43	E.	Andrew Ellicot; stone monument corner Parade and Front streets, in $\phi = 42° 08'.2$, $\lambda = 80° 05'.2$ W. American Almanac of 1861, p. 54, Boston, 1861.
4	1841, August 9.	0 30	W.	Dr. A. D. Bache, magnetic survey of Penn'a; Coast and Geodetic Survey Report for 1862, p. 213.
5	1855--	1 33		Annual Report of the Secretary for Internal Affairs, State of Pennsylvania, for 1877; Harrisburg, 1878.
6	1859, April.	1 34		Samuel Low; at meridian line established by him in cemetery. Mean of 9 years of observation, 1855 to 1863, inclusive. From Annual Report of Secretary for Internal Affairs, Commonwealth of Pennsylvania, Harrisburg, 1876, p. 20 A. In $\phi = 42° 09'$, $\lambda = 80° 05'$ W.
	1859, June	1 44.4		Lieut. W. P. Smith, U.S. survey of N. and N. W. Lakes; Capt. G. G. Meade in charge. At Presque Isle Harbor, in $\phi = 42° 09'.8$, $\lambda = 80° 05'.3$ W. [Mean of two values, $+ 1° 39'.2$.]
7	1862, August 6, 7	1 33		C. A. Schott, assistant Coast Survey. Same place as in Dr. Bache's survey, near Mr. Reed's house, 7th street, in $\phi = 42° 07'.5$, $\lambda = 80° 05'.3$ W. Coast Survey Report for 1862, p. 212.
	1862--	1 30		Samuel Low, observer. Annual Report of Secretary for Internal Affairs of Pa., 1885; Harrisburg, 1886.
8	1867, April.	2 13		Samuel Wilson; at meridian line in cemetery. Mean of 7 years of observation, 1864 to 1870, inclusive. Annual Rep. of Sec'y for Int. Aff. of Pa., 1876.
9	1873, June 12, 13.	2 00.7		Capt. A. N. Lee, U. S. Lake Survey. Report of Chief of Engineers for 1873, pp. 1195–1197; magnetic results 1870 to 1873. In $\phi = 42° 08'.2$, $\lambda = 80° 05'.3$ W.
	1873, October.	2 36		Samuel Wilson; at meridian line in cemetery. Mean of 6 years of observation, 1871 to 1876, inclusive. Annual Rep. of the Sec'y for Int. Aff. of Pa., 1876. [Mean, $+2° 18'.3$.]
10	1876--	2 50		Annual Report of the Sec'y for Internal Affairs of Pa., 1876.
11	1877, November.	3 00		Annual Report of the Sec'y for Int. Aff. of Pa., 1877; Harrisburg, 1878.
12	1883, November 9.	3 20		Platt, observer; Annual Rep. of the Sec'y for Internal Affairs of Pa., 1885; Harrisburg, 1886.
13	1885, September 11, 12, 14.	3 08.2	W.	J. B. Baylor, subasst. Coast and Geodetic Survey. Marine Hospital, in $\phi = 42° 09'$, $\lambda = 80° 05'$ W. MS. in archives of C. and G. S.

GROUP II.—*Series of Magnetic Stations, etc.*—Continued.

10.—CHICAGO, ILL.

$\phi=41° 50'.0$ $\lambda=87° 36'.7$ W. of Gr.

(Observatory, Dearborn University.)

		° ′	
1	1823..	6 12 E.	Major Long's expedition; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838. Locality assigned $\phi=42° 00'$, $\lambda=87° 40'$ W.
2	1857, July 23.	5 46.1	Lieut. Col. J. D. Graham; Pub. Doc. 35th Congress, 1st Sess., No. 42, 1858. In $\phi=41° 54'$, $\lambda=87° 38'$ W.
3	1878, September 2.	4 33.1 E.	Dr. T. E. Thorpe; grounds of the Chicago University, position as in heading. Proc. Roy. Soc. No. 200, 1880. [From these data only a rough result for secular-change can be had.—SCH.]

11.—CLEVELAND, OHIO.

$\phi=41° 30'.3$ $\lambda=81° 42'.0$ W. of Gr.

		° ′	
1	1796, September.	2 0 E.	Aug. Porter and Seth Pease; in $\phi=41° 30'$, $\lambda=81° 40'$ W. MS. compilation by Charles Whittlesey. March, 1860. In Coast Survey Archives.
2	1830..	1 20	Ahaz Merchant; Prof. E. Loomis' collection, Sill. Jour., vol. xxxix, 1840.
3	1831, August.	1 15	Edwin Foote; MS. compilation by C. Whittlesey, 1860.
4	1834, winter.	0 50	Ahaz Merchant; Prof. E. Loomis' collection, as above.
5	1838, winter.	0 35	Observer and reference as above.
6	1840..	0 19	Prof. E. Loomis; Gen. Sabine in Phil. Trans. Roy. Soc. 1872, contribution xiii. (Misprinted 1° 19′ E.) See Dr. C. Davies on "Surveying."
7	1841, May 1.	0 05.2	J. N. Pillsbury. MS. compilation by C. Whittlesey, 1860.
8	1845..	0 39 E.	From a chart of survey of N. and N. W. Lakes, Top. Eng'rs. Beacon Light in $\phi=41° 31'$, $\lambda=81° 41'.5$ W.
9	1859, July 5.	0 46 W.	Lieut. W. P. Smith, Top. Eng'rs; in $\phi=41° 30'$, $\lambda=81° 40'$ W. MS. by Ch. Whittlesey; also MS. by W. F. Raynolds, Major of Eng'rs, survey of N. and N. W. Lakes, Dec., 1865.
	1865..	1 12 E. (?)	MS. by W. F. Raynolds, Maj. of Eng'rs. [Value not used.—SCH.]
10	1871, November 9–11.	0 32.6 W.	Edw. Goodfellow, asst. Coast Survey; at Marine Hospital in $\phi=41° 30'.4$, $\lambda=81° 41'.5$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
11	1872, June 17, 18.	0 44.9	Capt. A. N. Lee, U. S. Lake Survey; Report of Chief of Eng'rs for 1873.
12	1873, June 16, 17.	0 50.9	Observer and reference as above.
13	1880, July 9, 10, 12.	1 38.5 W.	J. B. Baylor, U. S. Coast and Geodetic Survey; station of 1871, grounds of the City Hospital.

12.—OMAHA, NEBR., AND COUNCIL BLUFFS, IOWA.

$\phi=41° 15'.7$ $\lambda=95° 56'.5$ W. of Gr.

(Astron'l station, grounds of High School, Omaha.)

		° ′	
1	1819, September 22.	12 58.8 E.	Major Steph. H. Long, U. S. A.; Expedition to the Rocky Mts., Philadelphia, 1823 (2 volumes). At Engineers' cantonment in $\phi=41° 25'$, $\lambda=96° 00'$ W. [Reduction to Omaha, about —12′, hence decl'n, 12° 47′ E.—SCH.]

GROUP II.—*Series of Magnetic Stations, etc.*—Continued.

12.—OMAHA, NEBR., AND COUNCIL BLUFFS, IOWA—Continued.

		° ′	
2	1869, January 25–27. February 12, 13.	10 42.6 E.	Edw. Goodfellow, asst. Coast Survey; at astron'l station, Omaha; Coast and Geodetic Survey Report for 1881, App. 9.
3	1872, October 31.	10 44.2	Dr. T. C. Hilgard, Bache-Fund observer to National Academy; station as before (1869); Coast and Geodetic Survey Report for 1882, App. 14.
4	1877, October 13–18.	10 22.0	A. Braid, U. S. Coast Survey; station of 1869; Coast and Geodetic Survey Report for 1881, App. 9.
5	1878, August 30.	10 39.7	Dr. T. E. Thorpe; at Council Bluffs, near railway depot in $\phi=41° 15'.3$, $\lambda=95° 52'.4$ W.; Proc. Roy. Soc. No. 200, 1880.
6	1880, October 15, 17.	10 06.2 E.	J. B. Baylor, Coast and Geodetic Survey. Station on grounds of High School as in 1869, 1872, and 1877; Coast and Geodetic Survey Report for 1881, App. 9.

13.—PITTSBURGH, PA.

$\phi=40° 27'.6$ $\lambda=80° 00'.8$ W. of Gr.

(Allegheny Observatory, Allegheny.)

		° ′	
1	1840, August 10.	0 08 W.	Dr. A. D. Bache; at Homewood, in $\phi=40° 28'$, $\lambda=79° 59'.5$ W.; Coast Survey Report for 1862, App. 19.
2	1845, May 3.	0 33.1	Dr. John Locke, in $\phi=40° 26'$, $\lambda=79° 58'$ W.; Coast Survey Report for 1855, p. 304.
3	1878, September 5.	2 21.6	Dr. T. E. Thorpe; at Allegheny, grounds of the astron'l observatory, latitude and longitude as in heading. Proc. Roy. Soc. No. 200, 1880.
4	1884, September 26.	2 41	Hemmings; Annual Report of the Secretary for Internal Affairs of Pa. for 1885, Harrisburg, 1886, p. 16 A, p. 31 A.
5	1885, August 24, 25, 26.	2 55.7 W.	J. B. Baylor, subasst. Coast and Geodetic Survey; at Allegheny, grounds of the Observatory. MS. in archives of Survey.

DENVER, COLO.

$\phi=39° 45'.3$ $\lambda=104° 59'.5$ W. of Gr.

(Coast Survey Astron'l Station.)

		° ′	
1	1866, July.	15 0 E.	John Prince, Surveyor-General of Colorado; in $\phi=39° 45'$, $\lambda=105° 00'$ W. Letter to Office, of July 27, 1866.
2	1872, October 13, 14, 19.	14 44.7	Dr. T. C. Hilgard, Bache-Fund observer to National Academy; on Pierce's Block; Coast and Geodetic Survey Report for 1882, App. 14.
3	1873, August 14.	14 42.8	Edw. Smith, asst. Coast Survey; at astron'l station, in $\phi=39° 45'.3$, $\lambda=104° 59'.5$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
4	1878, August 8.	14 43.4	Dr. T. E. Thorpe; in Mrs. Craig's garden, $\phi=39° 45'.3$, $\lambda=104° 59'.6$ W.; Proc. Roy. Soc. No. 200, 1880.
	1878, September 3, 4, 5.	14 40.2 E.	J. B. Baylor, U. S. Coast Survey; corner of 17th st. and Broadway. Position as in heading; Coast and Geodetic Survey Report for 1881, App. 9. [Mean, — 14° 41′.8 for 1878.6.] [From the values collected at this station we can only deduce the average annual change between 1866 and 1878, which is + 1′.6—SCH.]

GROUP II.—*Series of Magnetic Stations, etc.*—Continued.

14.—MARIETTA, OHIO.

$\phi = 39° 25'$ $\lambda = 81° 28'$ W. of Gr.

		° ′	
1	1810..	2 36 E.	Jared Mansfield; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
2	1823–24.	3 30	Boye; at Parkersburg, W. Va., in $\phi = 39° 16'$, $\lambda = 81° 34'$ W. Boye's State map of Va. [Reduction to Marietta about $+5'$, hence decl'n $= -3° 25'$—SCH.]
3 {	1838..	1 29	Prof. E. Loomis; reference as above, in $\phi = 39° 25'$, $\lambda = 81° 26'$ W.
	1838..	1 36	B. E. Stone; near Marietta, in $\phi = 39° 31'$, $\lambda = 81° 26'$ W. Prof. E. Loomis' collection in Sill. Jour., vol. xxxix, 1840. [The weight ½ is assigned to the mean value.—SCH.]
4	1845, April.	2 25	Henk's Field-book.
5	1850..	1 25	A. D. Bache's table in Gillespie's Treatise on Land Surveying.
6	1864, January 26.	1 17.6 E.	A. T. Mosman, asst. Coast Survey; at Parkersburg, W. Va., in $\phi = 39° 16'.0$, $\lambda = 81° 34'.2$ W.; Coast and Geodetic Survey Report for 1881, App. 9. [Red'n to Marietta about $+5'$—SCH.]
7	1881, May 30, 31.	0 07.2 W.	J. B. Baylor, Coast and Geodetic Survey; at Parkersburg, station of 1864; reference as before. [Red'n to Marietta about $+5'$—SCH.]

15.—CINCINNATI, OHIO.

$\phi = 39° 06'.4$ $\lambda = 84° 29'.8$ W. of Gr. — Old Astronomical Observatory on Mt. Adams.

$\phi = 39° 08'.6$ $\lambda = 84° 25'.3$ W. of Gr. — New Astronomical Observatory on Mt. Lookout.

		° ′	
1	1806..	4 58 E.	Public surveys; Prof. E. Loomis' collection in Sill. Jour., vol. xxxix, 1840, in $\phi = 39° 06'$, $\lambda = 84° 27'$ W.
2	1810..	5 00	Jared Mansfield; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838, in $\phi = 39° 07'$, $\lambda = 84° 27'$ W.
3	1840, January 11.	4 46	Dr. John Locke; "Survey of Mineral Lands," Exec. Doc., 1839–40, vol. vi; in $\phi = 39° 06'$, $\lambda = 84° 27'$ W.
4	1845, April.	4 04	Dr. John Locke; Coast Survey Report for 1855, p. 304; in $\phi = 39° 06'$, $\lambda = 84° 22'$ W.
5	1880, November 27, 29, 30.	2 14.4 E.	J. B. Baylor, U. S. Coast and Geod. Survey; grounds of new astronomical observatory on Mt. Lookout; Coast and Geodetic Survey Report for 1881, App. 9.

16.—ST. LOUIS, MO.

$\phi = 38° 38'.0$ $\lambda = 90° 12'.2$ W. of Gr.

(Washington University.)

		° ′	
1	1819, June 17.	10 47.6 E.	Maj. S. H. Long; at St. Louis, in $\phi = 38° 36'$, $\lambda = 90° 06'$ W. [Longitude as given, about 5′ too small.—SCH.] Account of an expedition from Pittsburg to the Rocky Mts. in 1819 and 1820, by Maj. S. H. Long, Philadelphia, 1823.
2	1835..	8 49	Colonel Nicolls; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
3	1838..	7 45	De Ward, surveyor; on city commons. Letter of Thos. Featherson, of June 18, 1877; communicated by W. Eimbeck, asst. Coast Survey.
4	1855..	8 00	Colton's General Atlas, New York, 1873.

GROUP II.—*Series of Magnetic Stations, etc.*—**Continued.**

16.—ST. LOUIS, MO.—Continued.

		° ′	
5	1856, October 31,	6 23.1 E.	Karl Friesach; Berichte der Kais. Akad. der Wiss., Vienna, vol. xxix, 1858.
6	1872, June, July, and August.	6 37.5	Dr. T. C. Hilgard, Bache-Fund observer to National Academy. Two stations, south and west of court-house; first on Compton Hill, in $\phi=38°\ 37'.1$, $\lambda=90°\ 14'.0$ W., decl'n 6° 35′.2 E., and second near City Hospital, in $\phi=38°\ 36'.5$, $\lambda=90°\ 12'.7$ W., decl'n 6° 39′.9 E. Coast and Geodetic Survey Report for 1882, App. 14. [Result at a third station, 6° 48′.9 E., in field adjoining first position, not used.—SCH.]
7	1877, June.	6 30.5	Thomas Featherson, deputy county surveyor St. Louis Co.; from comparisons of 17 old lines run in the city commons in 1838 by De Ward, surveyor; communicated by W. Eimbeck, asst. Coast Survey; annual change since 1838 supposed to have been + 1′.91
8	1878, August 14, 15.	6 33.7	Prof. F. E. Nipher, Washington University. Observations in vacant square, S. E. corner of Garrison ave. and Dickson street; Trans. St. Louis Acad. of Sciences. [The instrument was loaned by the Coast Survey.—SCH.]
9	1879, September.	6 13.3	Observer as before; at corner of Garrison ave. and Glasgow place; communicated to office Oct. 14, 1879.
10	1886, October 3, 4, 5, 6.	6 10.6 E.	C. H. Sinclair, asst. Coast and Geodetic Survey; near N. W. corner of Tower Grove Park, St. Louis, in $\phi=38°\ 36'.7$, $\lambda=90°\ 15'.4$ W.; MS. in archives of Survey.

NASHVILLE, TENN.

$\phi=36°\ 10'.0$ $\lambda=86°\ 47'.0$ W. of Gr.

		° ′	
1	1829..	6 50 E.	Prof. Hamilton; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838, in $\phi=36°\ 10'$, $\lambda=86°\ 49'$ W.
2	1835..	7 07	Prof. Hamilton; reference as above.
3	1877, December 5, 6, 7.	5 14.9 E.	And. Braid, U. S. Coast Survey; grounds of Vanderbilt University, in $\phi=36°\ 09'.7$, $\lambda=86°\ 47'.6$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
			[The above values are insufficient to give satisfactory information as to the secular change.—SCH.]

17.—FLORENCE, ALA.

$\phi=34°\ 47'.2$ $\lambda=87°\ 41'.5$ W. of Gr.

(Coast Survey Station.)

		° ′	
1	1818..	6 35 E.	J. H. Weakly; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838; position assigned $\phi=34°\ 50'$, $\lambda=87°\ 47'$ W.
2	1835..	6 28	Observer and reference as before.
3	1865, April 17.	5 24	A. T. Mosman, asst. Coast Survey; Coast and Geodetic Survey Report for 1881, App. 9, in $\phi=34°\ 47'.2$, $\lambda=87°\ 41'.7$ W., near railway bridge.
4	1875, May 29.	5 14.4	F. E. Hilgard, Bache-Fund observer to National Acad.; in $\phi=34°\ 47'$, $\lambda=87°\ 42'$ W.; Coast and Geodetic Survey Report for 1882, App. 14.
5	1881, September 5, 6.	4 37.8 E.	J. B. Baylor; Coast and Geodetic Survey; grounds of College for Females, in $\phi=34°\ 47'$, $\lambda=87°\ 43'$ W.; Coast and Geodetic Survey Report for 1881, App. 9.

GROUP II.—*Series of Magnetic Stations, etc.*—Continued.

NATCHEZ, MISS.

$\phi = 31° 33'.5$ $\lambda = 91° 24'.0$ W. of Gr.

(Coast Survey Astronomical Station.)

		° ′	
1	1802..	9 0 E.	Dunbar; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838; in $\phi = 31° 34'$, $\lambda = 91° 25'$ W.
2	1872, April 21, 22.	7 14.8	Dr. T. C. Hilgard, Bache-Fund observer to National Acad.; in $\phi = 31° 34'$, $\lambda = 91° 24'$ W.; Coast and Geodetic Survey Report for 1882, App. 14.
3	1878–'79.	7 23 E.	W. H. Dennis, asst. Coast Survey; in $\phi = 31° 33'.5$, $\lambda = 91° 24'.1$ W. Marked on MS. triangulation sketch. [No satisfactory result can be had from these few observations.—SCH.]

18.—MOBILE, ALA.

$\phi = 30° 41'.4$ $\lambda = 88° 02'.5$ W. of Gr.

(Episcopal Church.)

		° ′	
	1809..	8 10 E.	J. H. Weakly; in $\phi = 30° 40'$, $\lambda = 88° 11'$ W.; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838. [Not used.—SCH.]
1	1814..	6 30	Kent; Encycl. Britan., 7th edition, 1842. For Mobile Bay; in $\phi = 30° 13'$, $\lambda = 88° 21'$ W. [Longitude defective.—SCH.]
2	1835..	7 12	J. H. Weakly; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
3	1840..	7 05	Chart of Mobile Bay by E. and G. W. Blunt; Coast Survey Report for 1845, p. 42.
4	1843..	6 56	Commander L. M. Powell, U. S. N. (in an official report). At Mobile Pt. Light, $\phi = 30° 13'.8$, $\lambda = 88° 01'.5$ W.; Coast Survey Report for 1855, p. 323. [Reduction to Mobile inappreciable.—SCH.]
5	1847, May 21–30.	7 04.1	R. H. Fauntleroy, asst. Coast Survey; at Fort Morgan, in $\phi = 30° 13'.9$, $\lambda = 88° 01'.2$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
6	1857, February 14–18.	6 52.2	Edw. Goodfellow, asst. Coast Survey; at Mobile City, near Episcopal Church, in $\phi = 30° 41'.6$, $\lambda = 88° 02'.6$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
7	1875, May 27.	6 07.0	J. M. Poole, Bache-Fund observer to National Academy; in part of city known as Summerville, in $\phi = 30° 42'$, $\lambda = 88° 03'$ W.; Coast and Geodetic Survey Report for 1882, App. 14.
8	1883, March 12.	5 17 E.	Lieut. E. S. Prime, U. S. S. Yantic; in $\phi = 30° 08'$, $\lambda = 88° 01'$ W.; Naval Professional Papers No. 19, Washington, 1886. [Reduction to Mobile inappreciable.—SCH.]

GROUP II.—*Series of Magnetic Stations, etc.*—Continued.

19.—NEW ORLEANS, LA.

$\phi = 29° 57'.2$ $\lambda = 90° 03'.9$ W. of Gr.

(Custom House.)

		° ′	
1	1720..	2 E.	Father Laval; Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838. [To this value the weight ½ is given.—SCH.]
2	1768..	7 50	Gauld; Gauld's survey of the Delta, near Pass à l'Outre. [Reduction to New Orleans, add 10′—SCH.]
3	1796..	5 06	A. G. Blanchard, city surveyor; change from 1796 to 1870, 2° east.
4	1806..	8 03	Lason; from 372 observations. Prof. E. Loomis' collection in Sill. Jour., vol. xxxiv, 1838.
5	1840..	8 20	From information recorded in General Land Office.
6	1856, December 28.	8 00	Karl Friesach; Berichte der Kais. Akad. der Wiss., Vienna, vol. xxix, 1858.
7	1858, April 6, 7.	7 51.5	G. W. Dean, asst. Coast Survey; near Canal and Basin sts., in $\phi = 29° 57'.4$, $\lambda = 90° 04'.4$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
8	1870..	7 06	M. J. Thompson, State engineer.
9	1872, February 10–15.	6 39.6	Dr. T. C. Hilgard, Bache-Fund observer to National Academy; observations at City Park, 6° 39′.8 E.; at Fair Grounds, 6° 39′.5 E. Position of City Park, in $\phi = 29° 55'.6$, $\lambda = 90° 07'.8$ W.; position of Fair Grounds, in $\phi = 29° 59'.1$, $\lambda = 90° 04'.8$ W. Coast and Geodetic Survey Report for 1881, App. 9, and for 1882, App. 14.
10	1880, March 24, 25.	6 27.6 E.	J. B. Baylor, U. S. Coast and Geodetic Survey; at Fair Grounds; Coast and Geodetic Survey Report for 1881, App. 9.

20.—SAN ANTONIO, TEX.

$\phi = 29° 25'.4$ $\lambda = 98° 29'.3$ W. of Gr.

(Arsenal Grounds.)

		° ′	
1	1825..	10 30 E.	Land Office record at San Antonio; communicated by Mr. J. B. Baylor.
2	1836..	9 45	
3	1874..	9 30	
4	1878, June 10, 11, 12.	9 22.3 E.	J. B. Baylor, U. S. Coast and Geodetic Survey; in Arsenal Grounds; position as in heading; Coast and Geodetic Survey Report for 1881, App. 9.

21.—KEY WEST, FLA.

$\phi = 24° 33'.5$ $\lambda = 81° 48'.5$ W. of Gr.

(Tift's Observatory.)

		° ′	
	1700.0.	5 E.	Edm. Halley's isogonic chart or Tabula Nautica Variationum Magneticarum Index, &c., anno 1700, reproduced in Greenwich observations for 1869. [Probably 1° in error; see values for Havana and Kingston; not used.—SCH.]
1	1829, February.	6 25	W. A. Whitehead; from a map of Florida by the Topographical Engineers, 1846.
2	1843..	6 02	Report of Commander L. M. Powell, U. S. N.; at Custom-House.
3	1849, August 19–21.	5 28.8 E.	J. E. Hilgard, asst. Coast Survey; at Sand Key, in $\phi = 24° 27'.2$, $\lambda = 81° 53'.1$ W.; Coast Survey Report for 1854, p. 145.

GROUP II.—*Series of Magnetic Stations, etc.*—Continued.

21.—KEY WEST, FLA.—Continued.

		° ′	
4	1860, February, March, June, and December.	4 46.6 E.	Prof. W. P. Trowbridge, asst. Coast Survey; at magnetic observatory, in $\phi=24° 33'.1$, $\lambda=81° 48'.5$ W. W. P. Trowbridge and S. Walker, observers. Coast and Geodetic Survey Report for 1881, App. 9.
5	1861, February, March, and April.	4 44.5	S. Walker, observer; at magnetic observatory. Means of monthly results and corrected for diurnal variation. In 1861, the observers were S. Walker and J. G. Oltmanns; in 1862, Walker, Oltmanns, and F. F. Ness; reference as before.
6	1862, May to December, inclusive.	4 39.9	
7	1863, January to December, inclusive.	4 36.8	
8	1864, January to December, inclusive.	4 33.9	
9	1865, January to December, inclusive.	4 31.5	
10	1866, January to April, inclusive.	4 29.8	
11	1879, March 24, 25, 26.	3 33.9	Lieut. S. M. Ackley, U. S. N., asst. Coast and Geod'c Survey; grounds of Army Hospital, in $\phi=24° 33'.3$, $\lambda=81° 47'.9$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
12	1884, April 4.	3 00	Lieut. C. Belknap, U. S. S. Vandalia; in $\phi=24° 27'$, $\lambda=81° 48'$ W.; Naval Professional Papers No. 19, Washington, 1886. [Red'n to Key West inappreciable.—SCH.]
	1884, May 10.	2 49 E.	Lieut. R. B. Peck, U. S. S. Swatara; in $\phi=24° 25'$, $\lambda=81° 46'$ W.; reference as before. [Reduction to Key West inappreciable; mean, $-2° 54'.5$—SCH.]

22.—HAVANA, CUBA.

$\phi=23° 09'.3$ $\lambda=82° 21'.5$ W. of Gr.

(Morro Light.)

		° ′	
	1700.0.	6 E.	Edm. Halley's isogonic chart for 1700; reproduced in Greenwich observations for 1869. [Not used.—SCH.]
1	1726..	4 24	Mathews; in $\phi=23° 02'$, $\lambda=81° 44'$ W.; Encycl. Britan., 1848. [Rough reduction to Havana $+10'$; hence 4° 34′ E.—SCH.]
2	1732, March and April.	4 30	J. Harris; off Havana, in $\phi=23° 08'$, $\lambda=82° 32'$ W.; Phil. Trans. Roy. Soc., vol. vii (abridged), 1724–34; also, Encycl. Metrop., 1848.
3	1815..	7 00	Encycl. Brit., 7th edition, 1842.
4	1816, August.	5 30	Bentley; reference as before.
5	1833.0.	6 50	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc., 1833, p. 1. [Supposed to be about 1° too great; see Key West and Kingston series; used temporarily 5° 50′ E.—SCH.]
6	1857, January 28.	5 15	Karl Friesach; Imp. Acad. of Sc., Vienna, vol. xxix, 1858.
7	1858..	5 45 E.	From a map of Cuba, 1860.

GROUP II.—*Series of Magnetic Stations, etc.*—Continued.

HAVANA, CUBA—Continued.

		° ′	
8	1879, March 13, 14, 15.	3 53.8 E.	Lieut. S. M. Ackley, U. S. N., asst. Coast and Geodetic Survey; at the College de Belen. [Annual change at the Collegio de Belen, according to Padre B. Viñes, S. J., director of observatory, 4′.5, decreasing for several years past. Letter of Lieut. Ackley of Mch. 21, 1879. The position of the Morro Light, as given in heading, is that determined by Lieut. Comdr. F. M. Green, U. S. N, and that of the Collegio de Belen is according to director Viñes (1885) in $\phi = 23° 08'.2$, $\lambda = 82° 22'.1$ W.—SCH.]
9	1884, April.	2 34 E.	Lieut. C. Belknap, U. S. S. Vandalia; in $\phi = 23° 02'$, $\lambda = 81° 43'$ W. Naval Professional Papers No. 19, Washington, 1886. [Reduced to Havana, 2° 44′ E.; double weight is temporarily assigned to this value.—SCH.]

23.—KINGSTON, PORT ROYAL, JAMAICA.

$\phi = 17° 55'.9$ $\lambda = 76° 50'.6$ W. of Gr.

(Port Royal Flagstaff.)

		° ′	
	1660..	6 30 E.	Declination in Jamaica according to J. Robertson; Phil. Trans. Roy. Soc., 1806. [Not used.—SCH.]
	1700..	6 30	According to Mountain's chart constructed in the year 1700 from Dr. Halley's tables; Long's History of Jamaica. [Halley's Tabula Nautica gives 7° E. for 1700. Not used.—SCH.]
1	1732, March and April.	6 02.5	J. Harris, at Black River; Phil. Trans. Roy. Soc., 1733. [Mean value of 6° and 6° 5′ E. Weight ½ assigned to this value.—SCH.]
2	1789 to 1793.	6 50	J. Leard; Chart of Port Royal.
	1791 to 1792.	6 45	
3	1806..	6 30	J. Robertson; Phil. Trans. Roy. Soc., 1806. The variation in Jamaica said to have been constant for 130 or 140 years.
4	1819..	4 50	De Mackau; in $\phi = 17° 55'$, $\lambda = 76° 09'$ W. } Becquerel's Traité du Magnétisme, Paris, 1846.
	1821..	4 50	De Mayne; in $\phi = 17° 55'$, λ 76° 53′ W.
5	1822..	4 54	Owen; Becquerel as above.
6	1832..	5 13	Foster; Becquerel as above.
7	1833 (?).	4 40	From a map of Kingston, date of 1854.
	1833.0.	6 30	Peter Barlow's isogonic chart for 1833; Phil. Trans. Roy. Soc., 1833. [Not used; value supposed to be about 1° too great; see Havana and Key West series.—SCH.]
8	1837, October.	4 18	Milne; in $\phi = 17° 56'$, $\lambda = 76° 51'$ W. Lieut. Col. Edw. Sabine's contributions to Terr. Mag. No. ix; Phil. Trans. Roy. Soc., 1849, part II.
9	1847, April.	3 40	Barnet; in $\phi = 17° 56'$, $\lambda = 76° 51'$ W.; reference as before.
10	1857, March 2.	3 40	Karl Freisach; Imp. Acad. of Sci., Vienna, vol. xxix, 1858.
	1866..	4 57	British Admiralty Chart of Jamaica, No. 446; variation in 1866, nearly stationary. [Not used.—SCH.]
11	1875..	4 00	British Admiralty Chart, No. 456; Port Royal and Kingston Harbor; annual decrease 2′.
12	1876..	3 35	Brit. Admiralty Chart, No. 762; West India Islands and Caribbean Sea.
13	1880..	3 06	Brit. Admiralty Chart; curves of equal magnetic variation, 1880.
14	1884, February 8.	2 20 E.	Lieut. R. B. Peck, U. S. S. Swatara; in $\phi = 17° 58'$, $\lambda = 76° 48'$ W.; Naval Professional Papers, No. 19, Washington, 1886. [Double weight is assigned to this value.—SCH.]

GROUP II.—*Series of Magnetic Stations, etc.*—Continued.

24.—PANAMA, NEW GRANADA.

$\phi = 8° 57'.1$ $\lambda = 79° 32'.2$ W. of Gr.

(Cathedral.)

		° ′		
	1700.0.	10	E.	Approximate value; Edm. Halley's isogonic chart for 1700, reproduced in Greenwich observations of 1869. [Not used.—SCH.]
1	1775, November.	7 49		Encycl. Brit., 7th edition, 1842.
2	1790, October 3.	7 49		Don A. Malaspina; Berliner Astronomisches Jahrbuch, Vol. 53, for 1828, p. 188.
	1791, December.	7 49		Encycl. Brit., 7th edition, 1842. [Probably same authority as for preceding date; not used.—SCH.]
3	1802..	8 00		Encycl. Brit., 7th edition, 1842.
4	1822..	7 00		Hall; in $\phi = 8° 58'$, $\lambda = 79° 21'$ W. Becquerel's Traité du Magnétisme, Paris, 1846. [The weight ½ is assigned to this value.—SCH.]
5	1837..	7 02		Sir Edw. Belcher; in $\phi = 8° 57'$, $\lambda = 79° 29'$ W. Phil. Trans. Roy. Soc., 1843.
6 {	1849..	7 15		Hughes; Brit. Admiralty Chart.
	1849..	6 55		Major W. H. Emory, Mexican Boundary Commissioner; in $\phi = 8° 57'$, $\lambda = 79° 29'$ W.; Coast Survey Report for 1856, p. 223. [Mean, 7° 5′ E.—SCH.]
7	1858..	6 17		Karl Friesach; in $\phi = 8° 57'$, $\lambda = 79° 31'$ W. Sir Edw. Sabine's Contributions to Terr. Mag., in Phil. Trans. Roy. Soc. for 1875.
8	1866, May 14.	5 56		Prof. W. Harkness, U. S. N.; in $\phi = 8° 55'$, $\lambda = 79° 30'.5$. Smithsonian Contributions to Knowledge, No. 239, Washington, 1873.
9	1873, December 25.	6 57		From log-books of the Benicia and Richmond; Hydrographic Office, Navy Dept., Washington; in $\phi = 7° 26'$, $\lambda = 79° 54'$ W., off Point Mala. [Reduced to Panama − 38′, hence decl'n 6° 19′ E.; weight ½.—SCH.]
10	1880..	5 24		Brit. Admiralty Chart; curves of equal magnetic variation, 1880.
11	1883, February 22.	5 02		Annales du Bureau des Longitudes, tome 3, Paris, 1883, p. 396–7. Promenade near the Cathedral, in $\phi = 8° 57'$, $\lambda = 79° 31'$ W.
12	1884, March 20.	5 23	E.	Lieut. C. Belknap, U. S. S. Vandalia; in $\phi = 9° 22'$, $\lambda = 79° 54'$ W. Naval Prof. Papers, No. 19, Washington, 1886. [Reduction to Panama inappreciable.—SCH.]

RESULTS FOR GROUP II.—Magnetic stations mainly in the central part of the United States between the Appalachian and Rocky Mountain ranges, with additions in British North America, Canada, the West Indies, and Central America.

Geographical positions and expressions for the secular variation of the magnetic declination D (+west,—east). The letter *m* stands for *t*—1850.0, or for the difference in time, expressed in years and fraction of a year, for any time *t* and the middle of the century, within the range of observation at any station.

No.	Name of station and State.	Latitude.	West Longitude.	The magnetic declination, expressed as a function of time.
		° ′	° ′	
1	York Factory, British North America.	56 59.9	92 26	D = + 4°.43 + 14°.11 sin (1.4 *m* — 95°.6)
2	Sault de Ste. Marie, Mich.	46 29.9	84 20.1	D = + 1.54 + 2.70 sin (1.45 *m* — 58.5)
3	Duluth, Minn., and	46 45.5	92 04.5	D = — 7.70 + 2.41 sin (1.4 *m* — 120.0)*
	Superior City, Wis.	46 39.9	92 04.2	
4	Pierrepont Manor, N. Y.	43 44.5	76 03.0	D = + 5.95 + 3.78 sin (1.4 *m* — 22.2)
5	Toronto, Canada.	43 39.4	79 23.5	D = + 3.60 + 2.82 sin (1.4 *m* — 44.7)
				+ 0.09 sin (9.3 *m* + 136)
				+ 0.08 sin (19 *m* + 247)
6	Grand Haven, Mich.	43 05.2	86 12.6	D = — 4.95 + 0.0380 *m* + 0.00120 m^2
7	Buffalo, N. Y.	42 52.8	78 53.5	D = + 3.66 + 3.47 sin (1.4 *m* — 27.8)
8	Detroit, Mich.	42 20.0	83 03.0	D = — 0.97 + 2.21 sin (1.5 *m* — 15.3)
9	Erie, Pa.	42 07.8	80 05.4	D = + 2.17 + 2.69 sin (1.5 *m* — 27.3)
10	Chicago, Ill.	41 50.0	87 36.7	D = — 6.00 + 0.0274 *m* + 0.00074 m^2*
11	Cleveland, Ohio.	41 30.3	81 42.0	D = + 0.10 + 2.07 sin (1.4 *m* — 6.2)
12	Omaha, Nebr.	41 15.7	95 56.5	D = — 11.62 + 0.0406 *m* + 0.00020 m^2*
13	Pittsburgh, Pa.	40 27.6	80 00.8	D = + 1.85 + 2.45 sin (1.45 *m* — 28.4)
14	Marietta, Ohio.	39 25	81 28	D = + 2.02 + 2.89 sin (1.4 *m* — 40.5)
15	Cincinnati, Ohio.	39 08.6	84 25.3	D = — 2.40 + 2.62 sin (1.42 *m* — 39.8)
16	Saint Louis, Mo.	38 38.0	90 12.2	D = — 6.04 + 2.60 sin (1.4 *m* — 48.0)*
17	Florence, Ala.	34 47.2	87 41.5	D = — 4.25 + 2.33 sin (1.3 *m* — 52.8)
18	Mobile, Ala,	30 41.4	88 02.5	D = — 4.38 + 2.69 sin (1.45 *m* — 76.4)
19	New Orleans, La.	29 57.2	90 03.9	D = — 5.61 + 2.57 sin (1.4 *m* — 61.9)
20	San Antonio, Tex.	29 25.4	98 29.3	D = — 7.40 + 2.88 sin (1.35 *m* — 81.8)*
21	Key West, Fla.	24 33.5	81 48.5	D = — 3.70 + 3.16 sin (1.35 *m* — 35.1)
22	Havana, Cuba.	23 09.3	82 21.5	D = — 4.32 + 2.45 sin (1.3 *m* — 20.8)*
23	Kingston, Port Royal, Jamaica.	17 55.9	76 50.6	D = — 4.48 + 2.28 sin (1.1 *m* + 10.1)
24	Panama, New Granada.	8 57.1	79 32.2	D = — 5.67 + 2.16 sin (1.1 *m* — 27.4)

* Expression very uncertain.

GROUP II.—*Comparison of observed and computed Magnetic Declinations.*

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
YORK FACTORY, BR. N. A.			
	°	°	°
1725.5	+19.00	+18.54	+ .46
1787.5	+ 5.00	+ 5.19	— .19
1819.7	— 6.00	— 5.01	— .99
1843.6	9.01	9.22	+ .21
1857.6	7.62	9.62	+2.00
1879.5	7.00	7.02	+ .02
1884.7	— 6.66	— 5.88	— .78
SAULT DE STE. MARIE, MICH.			
1790.5	0.00	+ 0.01	— .01
1843.5	— 1.13	— 0.96	— .17
1844.8	1.02	0.93	— .09
1845.5	0.77	0.91	+ .14
1846.8	0.67	0.87	+ .20
1856.7	— 0.54	— 0.49	— .05
1873.6	+ 0.08	+ 0.43	— .35
1879.8	1.02	0.82	+ .20
1880.6	+ 0.99	+ 0.88	+ .11
DULUTH, MINN., AND SUPERIOR CITY, WIS.			
1859.5	— 9.42	—10.01	+ .59
1861.5	10.20	10.04	— .16
1870.7	10.50	10.11	— .39
1871.5	10.67	10.11	— .56
1880.6	— 9.76	—10.05	+ .29
PIERREPONT MANOR, N. Y.			
1823.7	+ 2.27	+ 2.71	—0.44
1847.7	4.38	4.33	+0.05
1856.9	5.17	5.13	+0.04
1860.5	5.60	5.45	+0.15
1863.5	5.73	5.73	00
1864.3	5.83	5.81	+ .02
1865.4	6.00	5.91	+ .09
1866.7	6.25	6.03	+ .22
1867.6	6.17	6.11	+ .06
1868.4	6.17	6.19	— .02
1869.4	6.30	6.28	+ .02
1870.5	6.06	6.38	— .32
1874.8	+ 6.55	+ 6.77	— .22

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
TORONTO, CANADA.			
	°	°	°
1840.1	+ 1.45	+ 1.36	+ .09
1841.5	1.24	1.40	— .16
1842.5	1.32	1.45	— .13
1845.5	1.48	1.52	— .04
1846.5	1.51	1.54	— .03
1847.5	1.55	1.56	— .01
1848.5	1.59	1.57	+ .02
1849.5	1.62	1.59	+ .03
1850.5	1.64	1.62	+ .02
1851.5	1.68	1.66	+ .02
1853.5	1.77	1.76	+ .01
1854.5	1.80	1.82	— .02
1855.5	1.87	1.88	— .01
1856.5	1.94	1.95	— .01
1857.5	2.01	2.02	— .01
1858.5	2.07	2.08	— .01
1859.5	2.12	2.14	— .02
1860.5	2.18	2.20	— .02
1861.5	2.24	2.25	— .01
1862.5	2.26	2.29	— .03
1863.5	2.32	2.33	— .01
1864.5	2.36	2.37	— .01
1865.5	2.41	2.41	.00
1866.5	2.46	2.45	+ .01
1867.5	2.50	2.50	.00
1868.5	2.55	2.55	.00
1869.5	2.62	2.62	.00
1870.5	2.70	2.69	+ .01
1871.5	2.80	2.78	+ .02
1872.5	2.88	2.88	.00
1873.5	2.97	2.98	— .01
1874.5	3.07	3.09	— .02
1875.5	3.19	3.20	— .01
1876.5	3.31	3.30	+ .01
1877.5	3.41	3.41	.00
1878.5	3.52	3.50	+ .02
1879.5	3.62	3.58	+ .04
1880.8	3.68	3.67	+ .01
1884.6	+ 3.95	+ 3.87	+ .08
GRAND HAVEN, MICH.			
1825.5	— 5.25	— 5.16	— .09
1837.5	— 5.08	— 5.24	+ .16

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O — C.
GRAND HAVEN, MICH.—continued.			
	°	°	°
1859.6	— 4.40	— 4.47	+ .07
1865.6	4.25	4.07	— .18
1873.7	3.47	3.38	— .09
1880.5	— 2.43	— 2.68	+ .25
BUFFALO, N. Y.			
1797.5	0.00	+ 0.26	— .26
1798.5	+ 0.50	0.24	+ .26
1837.5	1.42	1.19	+ .23
1839.5	1.25	1.31	— .06
1845.5	1.42	1.71	— .29
1859.5	2.94	2.79	+ .15
1872.5	3.87	3.89	— .02
1873.5	3.97	3.97	.00
1885.7	+ 5.07	+ 4.98	+ .09
DETROIT, MICH.			
1810.5	— 2.80	— 3.10	+ .30
1822.5	3.22	2.82	— .40
1828.5	2.83	2.60	— .23
1835.5	2.17	2.30	+ .13
1840.5	1.97	2.06	+ .09
1859.3	0.70	1.01	+ .31
1865.5	0.67	0.66	— .01
1872.4	0.42	0.28	— .14
1873.4	0.29	0.22	— .07
1876.4	— 0.08	— 0.06	— .02
1885.7	+ 0.52	+ 0.40	+ .12
ERIE, PA.			
1786.8	+ 0.53	— 0.11	+ .64
1793.5	— 0.70	— 0.32	— .38
1795.5	— 0.72	— 0.37	— .35
1841.6	+ 0.50	+ 0.45	+ .05
1855.5	1.55	1.29	+ .26
1859.4	1.65	1.56	+ .09
1862.6	1.53	1.78	— .25
1867.3	2.22	2.11	+ .11
1873.6	2.31	2.55	— .24
1876.5	+ 2.83	+ 2.75	+ .08

Group II.—*Comparison of observed and computed Magnetic Declinations*—Continued.

ERIE, PA.—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
	°	°	°
1877.9	+ 3.00	+ 2.84	+ .16
1883.9	3.33	3.24	+ .09
1885.7	+ 3.14	+ 3.36	— .22

CHICAGO, ILL.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1823.5	— 6.20	— 6.21	+ .01
1857.6	5.77	5.75	— .02
1878.7	— 4.55	— 4.60	+ .05

CLEVELAND, OHIO.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1796.7	— 2.00	— 1.95	— .05
1830.5	1.33	1.04	— .29
1831.6	1.25	1.00	— .25
1834.1	0.83	0.89	+ .06
1838.1	0.58	0.70	+ .12
1840.5	0.32	0.59	+ .27
1841.3	0.09	0.55	+ .46
1845.5	— 0.65	— 0.35	— .30
1859.5	+ 0.77	+ 0.36	+ .41
1871.8	0.54	0.95	— .41
1872.5	0.75	0.98	— .23
1873.5	0.85	1.03	— .18
1880.5	+ 1.64	+ 1.33	+ .31

OMAHA, NEBR.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1819.7	—12.78	—12.67	— .11
1869.1	10.71	10.77	+ .06
1872.8	10.74	10.59	— .15
1877.8	10.37	10.34	— .03
1878.7	10.66	10.29	— .37
1880.8	—10.10	—10.18	+ .08

PITTSBURG, PA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1840.6	+ 0.13	+ 0.21	— .08
1845.3	0.55	0.44	+ .11
1878.7	2.36	2.41	— .05
1884.7	2.68	2.76	— .08
1885.6	+ 2.93	+ 2.82	+ .11

MARIETTA, OHIO.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
	°	°	°
1810.5	— 2.60	— 2.86	+ .26
1824.0	3.42	2.79	— .63
1838.5	1.54	2.39	+ .85
1845.3	2.42	2.10	— .32
1850.5	1.42	1.83	+ .41
1864.1	— 1.21	— 1.01	— .20
1881.4	+ 0.20	+ 0.20	.00

CINCINNATI, OHIO.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1806.5	— 4.97	— 4.97	.00
1810.5	5.00	5.01	+ .01
1840.0	4.77	4.52	— .25
1845.3	4.07	4.30	+ .23
1880.9	— 2.24	— 2.21	— .03

ST. LOUIS, MO.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1819.5	—10.79	— 8.64	—2.15
1835.5	8.82	8.46	—0.36
1838.5	7.75	8.38	+0.63
1855.5	8.00	7.72	—0.28
1856.8	6.39	7.66	+1.27
1872.6	6.63	6.77	+0.14
1877.5	6.51	6.47	—0.04
1878.6	6.56	6.40	—0.16
1879.7	6.22	6.33	+0.11
1886.8	— 6.18	— 5.88	—0.30

FLORENCE, ALA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1818.5	— 6.58	— 6.58	.00
1835.5	6.47	6.46	— .01
1865.3	5.40	5.51	+ .11
1875.4	5.24	5.04	— .20
1881.7	— 4.63	— 4.72	+ .09

MOBILE, ALA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1814.5	— 6.50	— 6.50	.00
1835.5	7.20	7.05	— .15
1840.5	— 7.08	— 7.07	— .01

MOBILE, ALA.—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
	°	°	°
1843.5	— 6.93	— 7.06	+ .13
1847.4	7.07	7.03	— .04
1857.1	6.87	6.84	— .03
1875.4	6.12	6.09	— .03
1883.2	— 5.28	— 5.66	+ .38

NEW ORLEANS, LA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1720.5	— 2.00	— 3.31	+1.31
1768.5	7.83	5.79	—2.04
1796.5	5.10	7.37	+2.27
1806.5	8.05	7.77	—0.28
1840.5	8.33	8.10	—0.23
1857.0	8.00	7.69	—0.31
1858.3	7.86	7.59	—0.27
1870.5	7.10	7.02	—0.08
1872.1	6.66	6.93	+0.27
1880.2	— 6.46	— 6.47	+0.01

SAN ANTONIO, TEX.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1825.5	—10.50	—10.01	— .49
1836.5	9.75	10.24	+ .49
1874.5	9.50	9.56	+ .06
1878.4	— 9.37	— 9.38	+ .01

KEY WEST, FLA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1829.1	— 6.42	— 6.52	+ .10
1843.5	6.03	5.89	— .14
1849.6	5.48	5.54	+ .06
1860.7	4.78	4.82	+ .04
1861.2	4.74	4.78	+ .04
1862.7	4.67	4.68	+ .01
1863.5	4.61	4.62	+ .01
1864.5	4.57	4.54	— .03
1865.5	4.53	4.47	— .06
1866.2	4.50	4.42	— .08
1879.2	3.56	3.46	— .10
1884.3	— 2.91	— 3.09	+ .18

GROUP II.—*Comparison of observed and computed Magnetic Declinations*—Continued.

HAVANA, CUBA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
	°	°	°
1726.5	— 4.57	— 4.26	— .31
1732.3	4.50	4.58	+ .08
1815.5	7.00	6.55	— .45
1816.6	5.50	6.52	+1.02
1833.0	5.83	5.99	+ .16
1857.1	5.25	4.81	— .44
1858.5	5.75	4.74	—1.01
1879.2	3.90	3.59	— .31
1884.3	— 2.73	— 3.33	+ .60

KINGSTON, JAMAICA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1732.2	— 6.04	— 6.46	+ .42
1791.8	— 6.78	— 6.32	— .46

KINGSTON, JAMAICA—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
	°	°	°
1806.5	— 6.50	— 5.88	— .62
1820.0	4.83	5.37	+ .54
1822.5	4.90	5.26	+ .36
1832.5	5.22	4.84	— .38
1833.5	4.67	4.80	+ .13
1837.8	4.30	4.61	+ .31
1847.3	3.67	4.20	+ .53
1857.2	3.67	3.78	+ .11
1875.5	4.00	3.07	— .93
1876.5	3.58	3.04	— .54
1880.5	3.10	2.90	— .20
1884.1	— 2.33	— 2.80	+ .47

PANAMA, NEW GRANADA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
	°	°	°
1775.8	— 7.82	— 7.71	— .11
1790.8	7.82	7.83	+ .01
1802.5	8.00	7.79	— .21
1822.5	7.00	7.49	+ .49
1837.5	7.03	7.09	+ .06
1849.5	7.08	6.69	— .39
1858.5	6.28	6.34	+ .06
1866.4	5.93	6.02	+ .09
1873.9	6.32	5.71	— .61
1880.5	5.40	5.44	+ .04
1883.1	5.03	5.33	+ .30
1884.2	— 5.38	— 5.29	—0.09

RESULTS FOR GROUP II—Continued.

Contents of columns: Year of first observation, and whole number of observations used in the discussion; probable error of an observation or of an expression; year of nearest easterly digression or magnetic elongation, with corresponding amount of maximum *east* declination; annual change for three modern epochs. East declination is indicated by a minus sign, as is also easterly increasing declination; westerly declination and westerly increase are indicated by a plus sign.

Number.	Station.	Year of first observation.	Number of observations.	Probable error of an observation.	Nearest epoch of easterly elongation.	Extreme value of declination at epoch.	Annual change in—		
							1885.0	1890.0	1895.0
				′		°	′	′	′
1	York Factory, Brit. N. A.	1725	7	±49	1854	− 9.7	+14.0	+16.0	+17.5
2	Sault de Ste. Marie, Mich.	1790	9	9	1828	− 1.2	+ 4.0	+ 4.1	+ 4.1
3	Duluth, Minn., & Superior City, Wis.	1859	5	28	1871 (?)	−10.1	+ 1.1 (?)	+ 1.5 (?)	+ 1.9 (?)
4	Pierrepont Manor, N. Y.	1823	13	7	1802	+ 2.2	+ 5.0	+ 4.6	+ 4.2
5	Toronto, Canada.	1840	39	2	----	----	+ 2.3	+ 3.8	+ 4.4
6	Grand Haven, Mich.	1825	6	9	1834	− 5.3	+ 7.3	+ 8.0	----
7	Buffalo, N. Y.	1797	9	10	1806	+ 0.2	+ 4.8	+ 4.5	+ 4.2
8	Detroit, Mich.	1810	11	10	1800	− 3.2	+ 2.8	+ 2.5	+ 2.1
9	Erie, Pa.	1786	13	13	1808	− 0.5	+ 3.8	+ 3.5	+ 3.2
10	Chicago, Ill.	1823	3	----	1832	− 6.2	+ 4.7	+ 5.2	+ 5.6
11	Cleveland, Ohio.	1796	13	13	1790	− 2.0	+ 2.2	+ 2.0	+ 1.7
12	Omaha, Nebr.	1819	6	10	----	----	+ 3.3	+ 3.4	+ 3.5
13	Pittsburgh, Pa.	1840	5	6	1808	− 0.6	+ 3.4	+ 3.2	+ 3.0
14	Marietta, Ohio.	1810	7	23	1815	− 2.9	+ 4.2	+ 4.1	+ 3.9
15	Cincinnati, Ohio.	1806	5	10	1815	− 5.0	+ 3.8	+ 3.7	+ 3.6
16	Saint Louis, Mo.	1819	10	29	1820 (?)	− 8.6	+ 3.8	+ 3.8	+ 3.7
17	Florence, Ala.	1818	5	7	1821	− 6.6	+ 3.2	+ 3.2	+ 3.2
18	Mobile, Ala.	1814	8	8	1841	− 7.1	+ 3.7	+ 3.9	+ 4.0
19	New Orleans, La.	1720	10	20	1830	− 8.2	+ 3.7	+ 3.8	+ 3.8
20	San Antonio, Tex.	1825	4	14	1844	−10.3	+ 3.3	+ 3.6	+ 3.8
21	Key West, Fla.	1829	12	3	1809	− 6.9	+ 4.4	+ 4.2	+ 4.0
22	Havana, Cuba.	1726	9	31	1797	− 6.8	+ 3.0	+ 2.9	+ 2.7
23	Kingston, Jamaiça.	1732	14	22	1759 (?)	− 6.8	+ 1.7	+ 1.5	+ 1.3
24	Panama, New Granada.	1775	12	±11	1793	− 7.8	+ 2.4	+ 2.4	+ 2.3

RESULTS FOR GROUP II—Completed.

Ephemeris of magnetic declinations. Computed magnetic declination at each station for every tenth year of the series, and after 1850 for every fifth year. A plus sign signifies westerly declination, a minus sign easterly declination. The first tabular result for any station indicates that the first observation made there falls between that tabular date and the next one following it.

Year (January 1).	York Factory, Brit. North Amer.	Sault de Ste. Marie, Mich.	Duluth, Minn., and Superior City, Wis.	Pierrepont Manor, N. Y.	Toronto, Canada.	Grand Haven, Mich.	Buffalo, N. Y.	Detroit, Mich.	Erie, Pa.	Chicago, Ill.	Cleveland, Ohio.	Omaha, Nebr.
	°	°	°	°	°	°	°	°	°	°	°	°
1700	----	----	-----	----	----	----	----	----	----	----	----	-----
10												
20	+18.4											
30	18.5											
40	+17.7											
1750	+16.1	----	-----	----	----	----	----	----	----	----	----	-----
60	13.8											
70	11.0											
80	7.7								+0.2			
90	+ 4.3	+0.0					+0.44		−0.2		−2.0	
1800	+ 0.9	−0.5	-----	----	----	----	+0.22	−3.2	−0.46	----	−1.9	-----
10	− 2.3	0.9					0.21	3.11	0.52		1.7	
20	5.1	1.1		+2.6		−5.0	0.41	2.90	0.39	−6.2	1.4	
30	7.7	1.16		3.05	+0.8	5.2	0.79	2.55	−0.09	6.2	1.06	
40	− 8.9	−1.04		+3.72	+1.32	−5.2	+1.35	−2.09	+0.36	−6.2	−0.61	
1850	− 9.6	−0.76	− 9.8	+4.52	+1.60	−4.95	+2.05	−1.56	+0.94	−6.0	−0.12	-----
55	9.7	0.57	9.9	4.96	1.85	4.74	2.43	1.26	1.26	5.8	+0.13	
60	9.5	0.34	10.02	5.41	2.17	4.45	2.84	0.99	1.60	5.6	0.38	−11.2
65	9.2	−0.07	10.08	5.87	2.39	4.11	3.25	0.69	1.94	5.4	0.63	10.97
70	− 8.6	+0.21	−10.11	+6.33	+2.66	−3.71	+3.67	−0.41	+2.30	−5.16	+0.87	−10.73
1875	− 7.9	+0.52	−10.10	+6.79	+3.14	−3.25	+4.09	−0.13	+2.65	−4.85	+1.10	−10.48
80	6.9	0.84	10.06	7.23	3.62	2.73	4.51	+0.13	2.99	4.51	1.31	10.23
85	5.8	1.18	9.98	7.6	3.88	2.15	4.91	0.37	3.32	4.14	1.51	9.98
90	4.6	1.52	9.9	8.0	4.12	1.5	5.30	0.58	3.62	3.7	1.68	9.68
95	− 3.2	+1.9	− 9.7	+8.4	+4.5	−0.8	+5.66	+0.78	+3.9	−3.3	+1.83	− 9.4

RESULTS FOR GROUP II—Completed.

Year (January 1).	Pittsburgh, Pa.	Marietta, Ohio.	Cincinnati, Ohio.	Saint Louis, Mo.	Florence, Ala.	Mobile, Ala.	New Orleans, La.	San Antonio, Tex.	Key West, Fla.	Havana, Cuba.	Kingston, Port Royal, Jamaica.	Panama, New Granada.
	°	°	°	°	°	°	°	°	°	°	°	°
1700	----	----	----	----	----	----	----	-----	----	----	----	----
10												
20							−3.3			−3.9		
30							3.6			4.5	−6.4	
40							−4.1			−5.0	−6.6	
1750	----	----	----	----	----	----	−4.7	-----	----	−5.5	−6.7	----
60							5.3			6.0	6.8	
70							5.9			6.3	6.7	−7.6
80							6.5			6.6	6.6	7.8
90							−7.1			−6.7	−6.4	−7.8
1800	----	----	−4.85	----	----	−5.81	−7.52	-----	----	−6.8	−6.1	−7.8
10		−2.9	5.00	−8.6	−6.50	6.30	7.88			6.7	5.8	7.7
20		2.8	5.00	8.6	6.58	6.71	8.11	−9.8	−6.76	6.5	5.4	7.5
30		2.7	4.83	8.6	6.54	6.97	8.18	10.1	6.49	6.1	5.0	7.3
40	+0.18	−2.33	−4.52	−8.3	−6.37	−7.07	−8.10	−10.3	−6.07	−5.7	−4.5	−7.0
1850	+0.68	−1.86	−4.08	−8.0	−6.11	−6.99	−7.88	−10.2	−5.52	−5.2	−4.1	−6.7
55	0.96	1.57	3.82	7.8	5.93	6.90	7.71	10.2	5.20	4.9	3.9	6.4
60	1.26	1.27	3.53	7.5	5.74	6.75	7.52	10.1	4.86	4.7	3.7	6.3
65	1.56	0.94	3.23	7.2	5.53	6.57	7.29	9.93	4.51	4.4	3.5	6.1
70	+1.87	−0.60	−2.92	−6.9	−5.30	−6.36	−7.05	−9.75	−4.15	−4.10	−3.3	−5.9
1875	+2.18	−0.26	−2.60	−6.6	−5.06	−6.12	−6.77	−9.54	−3.77	−3.82	−3.1	−5.7
80	2.49	+0.10	2.27	6.3	4.81	5.84	6.49	9.30	3.40	3.56	2.9	5.5
85	2.78	0.45	1.95	6.0	4.55	5.54	6.18	9.03	3.04	3.3	2.8	5.3
90	3.06	0.79	1.63	5.7	4.28	5.23	5.87	8.7	2.68	3.0	2.6	5.1
95	+3.3	+1.1	−1.3	−5.4	−4.0	−4.9	−5.6	−8.4	−2.33	−2.8	−2.5	−4.9

GROUP III.—*Collection of Magnetic Declinations from the earliest to the present time, observed on or near the Pacific coast of the United States and west of the Rocky Mountains and extending over the region from the Isthmus of Tehuantepec, Mexico, northward to Bering Strait and the Arctic Ocean, coast of Alaska.*

To these are added observations at a station in Kamtchatka and at two stations in the Sandwich Islands. This collection, however, comprises only places for which sufficient data were found for the discussion of the secular change of the declination.

Since the issue of the last edition of this paper a valuable collection of magnetic data has been published by Assistant G. Davidson, in Appendix No. 7, Report for 1885, entitled "Collection of some Magnetic Variations off the Coasts of California and Mexico, observed by Spanish Navigators in the last Quarter of the Eighteenth Century." The contents of this communication bearing directly upon our researches, it was submitted by me to a careful scrutiny, when its value became at once apparent, as it enabled me to assign for that early period a closely approximate value for the declination for any part of the coast between San Blas, a leading Mexican port at the time, and Vancouver Island. By means of these observations, when properly discussed, as satisfactory a value could be given as if it had been directly observed, and consequently I have introduced such results in the general collection of declinations at all places where observations were wanting about that period and in some instances made use of such values as checks on observations which appeared doubtful. It will therefore be proper to explain the method of procedure and give the results deduced before presenting the general collection of data at the secular-change stations on the Pacific coast.

All observations in question were made at sea, hence individually they give little information for any particular place, but collectively their value becomes apparent if it can be shown that the probable error of a single observation is reasonably small and the law of geographical distribution of the declination can be made out satisfactorily. This was effected by plotting all observed values for localities not more than about 4° of arc or about 240 nautical miles distant from the coast and representing the distribution of the declination as a function of the latitude and longitude disregarding the effect of the secular change during the interval 1774 to 1790; in other words, making no allowance for reduction to mean epoch.

To treat so large a number of observations by application of the method of least squares, the 122 observations selected as within our limit were united into mean values, for 7 groups, which could readily be marked out on the chart. No rejection was made and the values forming each group may be identified, if desired, by the epoch and their latitude and longitude without special reference to Appendix No. 7. These groups are as follows: In the table the groups are marked "A" to "G," and the headings No., τ, φ, λ, D indicate the running number, the year and fraction, the latitude, the west longitude, and observed declination, respectively.

No.	τ	φ	λ	D	No.	τ	φ	λ	D	No.	τ	φ	λ	D
GROUP A.					GROUP A—Continued.					GROUP B.				
		°	°	°			°	°	°			°	°	°
1	1775.2	21.4	110.3	−4.5	10	1779.9	21.6	110.8	−5.0	1	1774.1	20.8	113.8	−5.0
2	90.1	21.2	106.2	−6.0	11	79.9	21.6	110.3	−5.0	2	74.1	20.5	113.4	−5.0
3	90.9	22.7	111.4	−7.5	12	88.2	21.5	104.9	−5.0	3	75.2	20.6	113.9	−4.5
4	90.9	22.8	108.0	−7.0	13	88.9	23.8	109.4	−6.5	4	75.2	20.2	112.9	−4.5
5	90.9	22.7	107.0	−6.0	14	88.8	22.9	108.7	−5.0	5	75.2	19.8	110.7	−5.0
6	90.9	22.5	106.2	−5.0	15	88.8	22.7	108.6	−4.5	6	75.2	18.6	110.5	−5.0
7	79.9	23.0	111.0	−6.5	16	88.8	22.2	107.2	−4.5	7	75.2	18.6	110.7	−5.2
8	79.9	22.8	110.1	−6.0	17	1788.8	21.9	105.8	−4.5	8	79.2	20.6	112.4	−5.0
9	79.9	21.8	111.4	−5.0						9	79.2	20.4	110.0	−5.5

Group III.—*Collection of Magnetic Declinations from the earliest to the present time*—**Continued.**

No.	τ	φ	λ	D
Group B—Continued.				
		°	°	°
10	1779.2	20.0	111.6	— 6.0
11	79.2	20.1	116.8	— 7.0
12	79.1	20.5	111.8	— 5.0
13	79.2	20.4	114.5	— 6.0
14	88.2	20.2	112.7	— 5.5
15	88.2	20.3	113.8	— 5.5
16	88.2	20.4	116.6	— 6.0
17	90.1	20.5	114.2	— 6.9
18	1790.1	20.2	115.9	— 6.8
Group C.				
1	1779.9	22.3	112.7	— 5.5
2	88.9	24.6	111.6	— 7.0
3	88.8	23.6	112.8	— 5.0
4	79.9	27.1	116.5	— 8.5
5	79.9	26.1	115.6	— 7.5
6	79.9	25.3	114.6	— 7.0
7	79.9	24.4	118.5	— 7.0
8	79.9	23.4	117.3	— 7.0
9	79.9	23.0	116.0	— 6.5
10	79.9	22.8	115.1	— 6.0
11	79.9	22.5	114.3	— 5.5
12	88.9	25.7	112.6	— 9.0
13	88.8	27.1	117.0	— 6.0
14	88.8	25.7	115.2	— 5.0
15	88.8	25.0	114.6	— 5.5
16	88.8	24.7	113.9	— 5.3
17	88.8	24.2	113.5	— 5.2
18	90.8	24.8	115.5	— 8.0
19	90.8	23.8	114.1	— 9.0
20	1790.8	23.1	112.4	— 8.5
Group D.				
1	1779.8	30.9	119.8	—10.5
2	79.8	29.8	118.9	—10.0

No.	τ	φ	λ	D
Group D—Continued.				
		°	°	°
3	1779.9	23.8	117.4	— 9.5
4	88.9	33.4	117.9	—11.0
5	88.9	29.8	116.2	—10.0
6	88.7	32.6	120.8	— 9.0
7	88.7	31.7	118.7	— 8.5
8	88.8	30.6	116.4	— 8.0
9	88.8	28.3	119.0	— 6.9
10	90.8	32.8	121.8	—11.0
11	90.8	31.0	120.4	— 9.0
12	1790.8	29.4	119.3	— 8.5
Group E.				
1	1774.8	36.8	123.0	—11.0
2	74.8	36.2	122.0	—11.0
3	75.7	37.9	123.3	—16.0
4	75.8	37.7	123.8	—15.0
5	75.8	36.7	123.2	—14.0
6	79.8	37.6	123.2	—13.0
7	79.8	37.2	123.1	—12.5
8	79.8	36.0	122.6	—12.0
9	79.8	34.8	122.2	—11.0
10	79.7	37.8	122.8	—13.0
11	88.7	36.2	125.4	—10.5
12	88.7	35.2	124.2	—10.0
13	90.6	37.6	123.4	—14.5
14	90.8	35.3	123.0	—12.0
15	90.7	37.5	123.7	—13.3
16	1790.7	37.1	122.5	—13.0
Group F.				
1	1774.6	42.6	124.3	—15.5
2	74.6	39.8	124.3	—11.2
3	75.4	41.8	125.2	—14.0
4	75.4	41.5	124.8	—14.5

No.	τ	φ	λ	D
Group F—Continued.				
		°	°	°
5	1775.5	41.0	124.2	—14.0
6	75.6	42.4	125.0	—17.0
7	75.7	44.3	125.9	—18.0
8	75.7	42.6	124.6	—17.0
9	75.7	39.7	124.2	—16.0
10	79.7	43.8	128.8	—16.0
11	79.7	42.0	126.8	—15.5
12	79.7	40.9	125.4	—15.0
13	79.7	39.6	124.4	—14.0
14	79.7	39.5	124.6	—13.5
15	79.7	38.9	124.0	—13.0
16	88.7	40.0	125.5	—16.0
17	90.6	43.2	127.9	—15.0
18	90.7	41.3	126.0	—14.5
19	1790.7	39.4	125.4	—13.8
Group G.				
1	1774.6	48.3	125.2	—18.3
2	75.5	47.6	128.4	—17.0
3	75.5	47.5	126.5	—17.0
4	75.5	47.4	126.6	—17.5
5	75.5	46.5	128.4	—16.0
6	75.6	47.1	128.5	—18.0
7	75.6	49.2	128.0	—19.0
8	75.6	49.7	128.0	—18.0
9	75.6	46.2	124.3	—17.0
10	75.7	47.8	129.0	—19.0
11	90.2	49.9	127.6	—17.8
12	90.3	49.0	128.0	—17.1
13	90.3	48.7	128.4	—18.0
14	90.3	49.0	128.8	—18.5
15	90.6	48.2	125.2	—18.0
16	90.6	48.3	125.2	—17.0
17	90.6	48.4	126.4	—15.0
18	90.6	48.9	126.9	—15.5
19	90.6	49.5	127.2	—16.0
20	1790.6	49.6	127.7	—17.0

GROUP III.—*Collection of Magnetic Declinations from the earliest to the present time*—Continued.

RESULTS FOR EACH GROUP.

Group.	τ	φ	λ	D
		°	°	°
A	1785.9	22.3	108.7	− 5.5
B	1780.2	20.2	113.1	− 5.5
C	1785.1	24.5	114.7	− 6.7
D	1787.1	30.3	118.9	− 9.3
E	1782.2	36.7	123.2	−12.6
F	1779.8	41.3	125.3	−14.9
G	1783.0	48.3	127.2	−17.3
Mean	1783.3	31.9	118.7	−10.3

For the relation $D = f(\varphi, \lambda)$ I have found it sufficient to make use of the following terms only, others not having any sensible effect upon the result, nor would they be warranted by the uncertainties in the observations themselves:

$$D = D_0 + x.\Delta\varphi + y.\Delta\lambda \cos\varphi + z.\Delta\varphi^2$$

where

$$\Delta\varphi = \varphi - \varphi_0 = \varphi - 31^\circ.9$$
$$\Delta\lambda = \lambda - \lambda_0 = \lambda - 118^\circ.7$$

D_0=normal declination for epoch $1783.3 = -10^\circ.3$

D=declination for any place (within the geographical limits of the investigation) whose latitude is φ and whose longitude is λ. The conditional equations are as follows:

$$\begin{aligned}
+4.8 &= -\ \ 9.6\,x - 9.3\,y + \ \ 92\,z\\
+4.8 &= -11.7\,x - 5.3\,y + 137\,z\\
+3.6 &= -\ \ 7.4\,x - 3.6\,y + \ \ 55\,z\\
+1.0 &= -\ \ 1.6\,x + 0.2\,y + \ \ \ \ 3\,z\\
-2.3 &= +\ \ 4.8\,x + 3.6\,y + \ \ 23\,z\\
-4.6 &= +\ \ 9.4\,x + 5.0\,y + \ \ 88\,z\\
-7.0 &= +16.4\,x + 5.6\,y + 269\,z
\end{aligned}$$

and the normal equations become:

$$\begin{aligned}
\underline{666.7}\,x + 333.7\,y + 2456.4\,z + 299.6 &= 0\\
\underline{196.9}\,y + 250.1\,z + 153.3 &= 0\\
\underline{110957.0}\,z + 1036.9 &= 0
\end{aligned}$$

hence

$x = -0.381$

$y = -0.132$

$z = -0.0006$ and $D = -10^\circ.3 - 0.381\,\Delta\varphi - 0.132\,\Delta\lambda\cos\varphi - 0.0006\,\Delta\varphi^2$

with the following residuals:

Group.	Obs'd D.	Comp'd D.	O — C
	°	°	°
A	− 5.5	− 5.5	0.0
B	− 5.5	− 5.2	−0.3
C	− 6.7	− 7.0	+0.3
D	− 9.3	− 9.7	+0.3
E	−12.6	−12.6	0.0
F	−14.9	−14.6	−0.3
G	−17.3	−17.4	+0.1

GROUP III.—*Collection of Magnetic Declinations from the earliest to the present time*—Continued.

which is a sufficiently close representation. For the probable error of the mean of a group we have

$$r=0.674\sqrt{\frac{[vv]}{n-m}}=\pm 0^\circ.205 \text{ or } \pm 12'.$$

On an average the number of observations in a group is 17, hence the probable error r_0 of any individual observation for declination is $0.205\ \sqrt{17}$ or $\pm 0^\circ.845$ or $\pm 51'$, a tolerably fair value, considering the time when these observations were made. It also compares favorably with the estimated average probable error of an observation made by Vancouver.

To draw the isogonics as represented on the accompanying chart (No. 30) it was only necessary to find the roots of the above equation for certain assumed values for D, ranging from -5° to -18°, and plot the corresponding values of φ and λ for each line.

A comparison of the isogonics of 1783 with those of the present time shows that a century ago the general direction of the curves was not very unlike the present one, but they were less crowded than now. In the space between San Blas and the northern part of Vancouver Island we find a change of declination in 1783 of 13°, whereas in the same space we now have 15° of change, and, roughly speaking, the declination a century ago was 4° less easterly than at present in the region of San Blas and 6° less than at present at Vancouver Island.

Series of Magnetic Stations mainly on the Pacific Coast and in the region west of the Rocky Mountains.

The stations of this western series are irregularly scattered over the region extending from the Isthmus of Tehuantepec, Mexico, to the Arctic Ocean, Alaska. Added thereto is a station in Kamtchatka, Eastern Siberia, and two on the Sandwich Islands group.

In this series the observations for magnetic declination have been collected and discussed for secular variation at the following places:

1. Acapulco, Mexico.
2. Vera Cruz, Mexico.
3. City of Mexico, Mexico.
4. San Blas, Mexico.
5. El Paso, Texas.
6. Magdalena Bay, Lower Cal.
7. San Diego, Cal.
8. Santa Barbara, Cal.
9. Monterey, Cal.
10. San Francisco, Cal.
11. Salt Lake City, Utah.
12. Cape Mendocino, Cal.
13. Vancouver, Wash. Ter'y.
14. Wallula, Wash. Ter'y.
15. Cape Disappointment, Wash. Ter'y.

.. Olympia, Wash. Ter'y.

16. Seattle, Duwamish Bay, Wash. Ter'y.
17. Port Townsend, Wash. Ter'y.
18. Nee-ah Bay, Cape Flattery, Wash. Ter'y.
19. Nootka, Vancouver Island.
20. Sitka, Alaska.
21. Port Mulgrave, Yakutat Bay, Alaska.
22. Port Etches, Alaska.
23. St. Paul, Kadiak Island.
24. Captain's and Iliuliuk harbors, Unalashka Is'd.
25. Port Clarence, Alaska.
26. Chamisso Island, Kotzebue Sound.
27. Petropavlovsk, Kamtchatka.
28. Kailua, Is'd of Hawaii, Sandwich Is'ds.
29. Honolulu, Is'd of Oahu, Sandwich Is'ds.

The first column of the record for any station contains the running number of the values used in the discussion, the second the date of observation, the third the observed value, and the fourth the name of the observer, the geographical position of the station, the reference to publication, and other pertinent remarks.

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

1.—ACAPULCO, MEXICO.

$\phi=16° 50'.5$ $\lambda=99° 53'.5$ W. of Gr.

(South of Fort San Diego.)

		° ′	
1	1744..	3 E.	Anson; Hansteen's Magnetismus der Erde, 1819.
2	1791, April 29.	7 44	Don A. Malaspina, observed on land. Berliner Jahrbuch, vol. 53, for 1828.
3	1822..	8 40	Hall; in $\phi=16° 50'$, $\lambda=99° 51'$ W. Becquerel's Traité du Magnétisme, Paris, 1846.
4	1828..	9 07	Capt. Beechey; Becquerel, as above.
5	1837..	8 23	Sir Edw. Belcher; Fort San Diego, in $\phi=16° 50'.9$, $\lambda=99° 52'.2$ W. Admiralty chart of Acapulco.
	1838..	8 13	Sir Edw. Belcher; Phil. Trans. Roy. Soc., 1843.
	1838..	8 17	Du Petit Thouars; Voyage of the Frigate Venus.
	1841..	8 17	Duflot de Mofras' Explorations of Oregon, Paris, 1844. [Probably Du Petit Thouars' value; not used.—SCH.]
6	1866, May 30.	8 22	W. Harkness, Prof. U. S. N., in $\phi=16° 50'.1$, $\lambda=99° 52'.3$ W. Observations on Terrestrial Magnetism, Smithsonian Contributions to Knowledge, No. 239, 1873, p. 61.
7	1874, March 17.	8 38.7	G. Dewey, Comdr. U. S. Str. Narragansett, Lieuts. Z. L. Tanner and E. J. Young, observers; in $\phi=16° 50'.5$, $\lambda=99° 55'.4$ W.
8	1880, November 23, 24.	7 56.6	H. E. Nichols, Lieut. U. S. N., assist. U. S. Coast and Geodetic Survey; Cocoanut Grove, close to Prof. Harkness' station of 1866; in $\phi=16° 49'.2$, $\lambda=99° 56'.3$ W.
9	1882, November 18.	7 54 E.	U. S. S. Ranger, Lieut. W. P. Ray, in $\phi=16° 51'$, $\lambda=99° 56'$ W. Naval Professional Papers No. 19, Washington, 1886.

2.—VERA CRUZ, MEXICO.

$\phi=19° 12'.0$ $\lambda=96° 08'.8$ W. of Gr.

(Castle San Juan d'Ulloa.)

		° ′	
1	1726 to 1727.	2 15 E.	Joseph Harris; Phil. Trans. Roy. Soc. (abridged), 1824–'34.
2	1769..	6 40	Encycl. Brit., seventh edition, 1842.
	1769, March 15.	6 28	
3	1776..	7 30	Don Ulloa; Encycl. Brit., seventh edition, 1842.
4	1815..	10 37	Malony; Encycl. Brit., seventh edition, 1842. [Weight ¼ assigned to this value.—SCH.]
5	1819, April 27.	9 16	Wise; Encycl. Brit., seventh edition, 1842.
6	1839..	8 22	Behard; $\phi=19° 12'$, $\lambda=96° 09'$ W. Phil. Trans. Roy. Soc., Sir Edw. Sabine's Contributions to Terr. Magn., No. xiv, vol. 165, 1875.
7	1856, August 7, 8.	8 17	August Sonntag; in $\phi=19° 12'$, $\lambda=96° 09'$ W., at the villa la Guaca, 200 yds. south of the city; Smithsonian Contributions to Knowledge, Washington, 1860; also, Coast Survey Report for 1856, p. 214.
8	1861..	8 20	English Admiralty Chart, No. 523, corrected to 1861.
9	1880, February 10, 11, 12.	7 26.3 E.	Lieut. S. M. Ackley, U. S. N., asst. U. S. Coast and Geodetic Survey; north-east bastion of Castle San Juan d'Ulloa, $\phi=19° 12'.2$, $\lambda=96° 08'.5$ W.

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

3.—CITY OF MEXICO, MEXICO.

$\phi = 19° 26'.0$ $\lambda = 99° 11'.6$ W. of Gr.

(Observatorio Nacional.)

		° ′		
1	1769, June.	5 20	E.	Don Alzate; Hansteen's Magnetismus der Erde, 1819.
	1769, December.	5 35		Don Alzate; reference as above.
2	1775..	6 42		Velasquez de Leon; Memoria del Observatorio Meteorologico Central de Mexico; Por V. Reyes, Mexico, 1880.
3	1803, December	8 08		Alex. von Humboldt; Hansteen's Magnetismus der Erde, 1819.
4	1849..	8 30.2		Gomez de la Cortina; Memoria del Observatorio Meteorologico Central de Mexico; Por V. Reyes, Mexico, 1880.
5	1850..	8 35.2		Velasquez y Teran; F. Diaz Covarrubias' Tratado de Topografia y Geodesia, Mexico, 1869, tomo 1, p. 221.
6	1856, December 10-17.	8 46		August Sonntag; Observations on Terr. Mag. in Mexico, Smithsonian Cont's to Knowl., Washington, 1860; also Coast Survey Report for 1856, p. 214.
7	1858..	8 22.3		Alamazan; in Mem. del Observatorio Central; F. Diaz Covarrubias' Tratado de Top. y Geod., Mexico, 1869.
8	1860..	8 30		Salazar Llarregui; in Mem. del Observatorio Central; F. Diaz Covarrubias' Tratado, as above.
9	1862..	8 20.5		Diaz Covarrubias; Tratado, as above.
	1862..	8 34.8		Iglesias; Memoria del Observatorio Meteorologico Central de Mexico; Por V. Reyes, Mexico, 1880.
10	1866..	8 08.5		Ponce de Leon; Tratado de Topografia y Geodesia, Mexico, 1869, tomo 1, p. 221.
	1867..	8 09.3		
11	1868..	8 10.0		Fernandez y Diaz Covarrubias; Tratado, as before.
12	1879, September, October, November, December.	8 34.5		Memoria sobre el Departmento Magnetico del Oservatorio Meteorologico Central de Mexico, Por V. Reyes, Mexico, 1880. [The weight one-half is given to this value.—SCH.]
13	1884, April 5, 8, 9, 11, 15, 19.	8 19.0	E.	Observatorio Central (at Tacubaya), M. Barcena, director; official, newspaper slip communicated by the Mexican Consul at San Francisco. The observations of April 15 were made by Prof. G. Davidson, assist. Coast and Geodetic Survey; he found 8° 13′.9 E.

4.—SAN BLAS, MEXICO.

$\phi = 21° 32'.5$ $\lambda = 105° 18'.4$ W. of Gr.

(Custom House.)

		° ′		
1	1788, March 9.	5	E.	Don Esteban Martinez; in the Princessa; $\phi = 21° 30'$, $\lambda = 105\frac{1}{2}°$ W. Asst. Davidson's collection, Coast and Geodetic Survey Report for 1885, Appendix No. 7.
2	1791, April 12.	7 28		Don A. Malaspina; observed on shore. Berliner Astron. Jahrbuch, vol. 53, for 1828; also Encycl. Brit., seventh edition, 1842.
3	1821–'22.	8 40		Hall; Encycl. Brit., seventh edition, 1842.
	1828..	11 06	E.	Capt. F. W. Beechey; Beechey's Narrative of a Voyage to the Pacific, 1825–'28; also Becquerel's Traité du Magnétisme, Paris, 1846. [Not used.—SCH.]

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

SAN BLAS, MEXICO—Continued.

		° ′	
4	1837..	8 34 E.	Sir Edw. Belcher; in $\phi=21° 32'$, $\lambda=105° 16'$ W. Phil. Trans. Roy. Soc., 1843.
	1837..	9 09	Du Petit Thouars; Voyage de la Vénus, 1841. Gen. Sir Edw. Sabine's Cont's to Terr. Mag., No. xiv. Phil. Trans. Roy. Soc.. vol. 165, part 1, 1875; position in $\phi=21° 32'$, $\lambda=105° 16'$ W.
5	1838..	8 47	Sir Edw. Belcher; in the Sulphur; reference as abo
6	1839..	9 00	Sir Edw. Belcher; Phil. Trans. Roy. Soc., 1843.
7	1841..	9 12	Duflot de Mofras' Exploration of Oregon, Paris, 1844.
8	1874, February 23, 24, 26.	9 08.2	G. Dewey, Comdr. U. S. S. Narragansett, Lieuts. Z. L. Tanner and E. J. Young, observers, in $\phi=21° 32'.4$, $\lambda=105° 18'.7$ W.
9	1880, December 5.	9 18.1 E.	H. E. Nichols, Lieut. U, S. N., asst. U. S. Coast and Geodetic Survey; near Custom House, station of Sir E. Belcher of 1839; in $\phi=21° 32'.2$, $\lambda=105° 18'.1$ W.

5.—EL PASO, TEX.

$\phi=31° 46'$ $\lambda=106° 30'$ W. of Gr.

		° ′	
1	1852..	12 24 E.	Major W. H. Emory, Commissioner United States and Mexican boundary survey; Amer. Acad. of Sci., vol. vi, new series, 1856. At Frontera in $\phi=31° 49'$, $\lambda=106° 29'$ W.
2	1859, January 20.	12 25.0	J. H. Clark, U. S. Commissioner; Report of Commissioner of General Land Office, 47th Cong., Sen. Exec. Doc. No. 70, Washington, 1882; at Frontera in $\phi=31° 49'$, $\lambda=106° 33'$ W.
3	1878..	12 25.2	At astronomical monument, Fort Bliss; in $\phi=31° 45'.5$, $\lambda=106° 29'.1$ W. Report of Chief of Engineers, U. S. A. for 1879, vol. iii.
4	1884, April 8.	12 05 E.	Prof. G. Davidson, asst. Coast and Geodetic Survey; about 200 yds. north of R. R. depot, in $\phi=31° 46'$, $\lambda=106° 30'$ W. MS. at C. and G. Survey Office.

6.—MAGDALENA BAY, LOWER CALIFORNIA.

$\phi=24° 38'.4$ $\lambda=112° 08'.9$ W. of Gr.

(Near village on Man-of-War Cove.)

		° ′	
1	1783.3.	6 47 E.	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
2	1837..	8 15	Du Petit Thouars; voyage of the Frigate Venus.
	1837..	8 17	Voyage of the Frigate Venus. } Gen. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., vol. 165, part 1, 1875; Cont's to Terr. Mag., xiv.
3	1839..	9 15	Sir Edw. Belcher in $\phi=24° 38'$, $\lambda=112° 07'$ W. } Gen. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., vol. 165, part 1, 1875; Cont's to Terr. Mag., xiv.
	1841..	8 15	Duflot de Mofras; Explorations of Oregon, Paris, 1844; in $\phi=24° 36'$, $\lambda=112° 05'$ W. [Not used.—SCH.]
4	1866, June 9.	10 40.5 E.	W. Harkness, Prof. U. S. N.; Cruise of the Monadnock, 1865–'6, Smithsonian Contributions to Knowledge, No. 239, Washington, 1873; in $\phi=24° 40'$, $\lambda=112° 07'$ W.

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—**Continued.**

MAGDALENA BAY, LOWER CALIFORNIA—Continued.

		° ′	
5	1871, March and June.	11 00 E.	G. Bradford, asst. Coast Survey, near village on Man-of-War Cove, in $\phi = 24° 37'.5$, $\lambda = 112° 13'.3$ W. Chart in Coast Survey archives.
6	1873, March 5, 6, 7.	10 36.6	W. Eimbeck, assist. Coast Survey, near village on Man-of-War Cove, in $\phi = 24° 38'.4$, $\lambda = 112° 08'.9$ W., near Belcher's and Bradford's stations. Record in Coast Survey archives.
	1873, June 23.	10 30.8	G. Dewey, Comdr. U. S. S. Narragansett; Lieuts. Z. L. Tanner and E. J. Young, observers. [Double weight given to this value.—SCH.]
7	1881, February 24.	10 29.1 E.	H. E. Nichols, Lieut. Comdr. U. S. N., assist U. S. Coast and Geodetic Survey; at Eimbeck's station of 1873, in $\phi = 24° 38'.4$, $\lambda = 112° 08'.9$ W. [Double weight given to this value.—SCH.]

7.—SAN DIEGO, CAL.

$\phi = 32° 42'.1$ $\lambda = 117° 14.3'$ W. of Gr.

(La Playa, Point Loma.)

		° ′	
1	1783.3.	10 26 E.	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
2	1792..	11 0	Capt. G. Vancouver; Vancouver's Voyage of Discovery, etc., 1790–'95, vol. 2, p. 475, London, 1798; also Hansteen's Magnetismus der Erde, 1819. In $\phi = 32° 39'$, $\lambda = 117° 17'$ W.
	1793..	11 0	Reference as above; in $\phi = 32° 42'$, $\lambda = 116° 53'$ W. Observed on board ship on or near the coast. [Not used—SCH.]
3	1839..	12 20.6	Sir Edw. Belcher; in $\phi = 32° 41'$, $\lambda = 117° 13'$ W. Phil. Trans. Roy. Soc., 1841.
	1841..	11 0	Duflot de Mofras, Explorations of Oregon, Paris, 1844; in $\phi = 32° 39'.5$, $\lambda = 117' 17'$ W. [Not used.—SCH.]
4	1851, April 28 to May 7.	12 28.8	G. Davidson, asst. Coast Survey; near La Playa, in $\phi = 32° 42'.2$, $\lambda = 117° 14'.6$ W., Coast Survey Report for 1856, p. 229.
5	1853, October 15.	12 31.7	Lieut. W. P. Trowbridge, asst. Coast Survey; at La Playa, near the custom house. Coast Survey Report for 1856.
6	1866, June 15.	13 09.4	W. Harkness, Prof. U. S. N.; in $\phi = 32° 42'$, $\lambda = 117° 13'$ W., at La Playa; Smithsonian Contributions to Knowledge, No. 239, Washington, 1873.
	1871, May 28, 29, 30.	14 46.7	G. Davidson, Assist. Coast Survey, at New San Diego; in $\phi = 32° 43'.1$, $\lambda = 117° 09'.7$ W., Coast and Geodetic Survey Report for 1881, App. 9. [Not used, distance from La Playa too great and reduction uncertain.—SCH.]
7	1872, November 19, 20, 21.	13 19.4	G. Davidson, assist. Coast Survey, and S. R. Throckmorton, aid; near La Playa, in $\phi = 32° 42'.2$, $\lambda = 117° 14'.6$ W.; station of 1851. Coast and Geodetic Survey Report for 1881, App. 9.
	1879..	12 55	Capt. W. A. Jones, from a plan of New San Diego, showing U. S. Barracks. [Not used.—SCH.]
8	1881, April 6.	13 27.6 E.	H. E. Nichols, Lieut. Comdr. U. S. N., asst. Coast and Geodetic Survey, at Davidson's station of 1851, in $\phi = 32° 42'.2$, $\lambda = 117° 14'.5$ W. Coast and Geodetic Survey Report for 1881, Appendix 9.

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

8.—SANTA BARBARA, CAL.

$\phi = 34° 24'.2$ $\lambda = 119° 43'.0$ W. of Gr.

(Astronomical station of 1869.)

		° ′	
1	1783.3.	11 22 E.	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
	1793, November.	10 15	Capt. G. Vancouver; Hansteen's Magnetismus der Erde, 1819. In $\phi = 34° 24'$, $\lambda = 119° 16'$ W. [Not used—SCH.]
2	1839..	13 28	Sir Edw. Belcher; Phil. Trans. Roy. Soc., 1841. In $\phi = 34° 24'$, $\lambda = 119° 41'$ W.
3	1869, November 16–19.	15 11.9	S. R. Throckmorton (G. Davidson, assist., chief of party), Coast and Geodetic Survey Report for 1881, Appendix 9. In $\phi = 34° 24'.2$, $\lambda = 119° 42'.8$ W.; at outermost spur of hill.
4	1881, April 14.	14 51.9 E.	H. E. Nichols, Lieut. Comdr. U. S. N., assist. Coast and Geodetic Survey; Report for 1881, App. 9. Near long wharf and the Burton House, in $\phi = 34° 24'.6$, $\lambda = 119° 41'.5$ W.

9.—MONTEREY, CAL.

$\phi = 36° 36'.1$ $\lambda = 121° 53'.6$ W. of Gr.

(Custom House.)

		° ′	
1	1783.3.	12 26 E.	Deduced from 122 observations by Spanish navigators along the coast from San Blas to Nootka; see preceding investigation.
2	1786, September 14, 15.	11 48	La Perouse (J. F. G. de); at sea, a few miles from the anchorage, variation —11° 57′; and twenty miles north and west from Pt. Pinos —11° 39′. Voyage autour du monde, Paris, 1797, vol. 3, pp. 302 and 390. Communicated by Mr. Marcus Baker, C. and G. Survey.
3	1791, September 23.	10 56	Don A. Malaspina; Berliner Astron. Jahrbuch, vol. 53, for 1828. Observations made on shore.
4	1792, December.	12 22	Capt. G. Vancouver; in $\phi = 36° 36'$, $\lambda = 121° 34'$ W.; Vancouver's Voyage of Discovery, etc., 1790–'95, vol. ii, p. 51; London, 1798; also Hansteen's Magnetismus der Erde, 1819.
5	1794, November 13.	12 22	Capt. G. Vancouver; in $\phi = 36° 36'$, $\lambda = 121° 51'$ W.; Vancouver's Voyage of Discovery, etc., 1790–'95, vol. iii, p. 337; also Hansteen's Magnetismus der Erde, 1819. Probably taken on shore.
	1818, September.	16 30	Capt. Golovnin (V. M.); apparently at Presidio, in $\phi = 36° 36'.2$. Voyage around the World, St. Petersburg, 1822, vol. 2. Communicated by Mr. Marcus Baker, Coast Survey. [Not used, apparently about 3° in error—SCH.]
	1827..	15 38	Capt. F. W. Beechey; Phil. Trans. Roy. Soc., vol. 165, 1875, Sir Edw. Sabine's Cont's to Terr. Mag., No. xiv. [Not used—SCH.]
6	1837..	14 30	Du Petit Thouars; Voyage of the Frigate Venus. Near Monterey.
7	1839..	14 30	Sir Edw. Belcher; in $\phi = 36° 36'$, $\lambda = 121° 53'$ W. Phil. Trans. Roy. Soc., 1841.
8	1841..	15 00	Duflot de Mofras; Exploration of Oregon, Paris, 1844, at Presidio, in $\phi = 36° 36'$, $\lambda = 121° 53'$ W.
9	1843..	14 00 E.	Chart of the harbor of Monterey, surveyed by Comdr. T. A. Dornin; position of fort $\phi = 36° 36'.4$, $\lambda = 121° 52'.4$ W.

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—**Continued.**

MONTEREY, CAL.—Continued.

		° ′	
10	1851, February 8.	14 58.3 E.	G. Davidson, asst. Coast Survey; at Point Pinos, astronomical station, in $\phi=36°\ 37'.8$, $\lambda=121°\ 55'.5$ W. Coast Survey Report for 1856, p. 229.
11	1854, May 29, 30.	14 58.9	W. P. Trowbridge, Lieut. U. S. A., assist. Coast Survey. Station near barracks of redoubt, in $\phi=36°\ 36'.2$, $\lambda=121°\ 53'.8$ W. Coast and Geodetic Survey Report for 1881, Appendix 9.
12	1873, August 30, 31, September 1.	15 55.3	G. Davidson, asst. Coast Survey, and S. R. Throckmorton, aid; near astronomical station; in $\phi=36°\ 37'.8$, $\lambda=121°\ 55'.6$ W. Coast and Geodetic Survey Report for 1881, App. 9.
13	1881, April 20.	15 53.9 E.	H. E. Nichols, Lt. Comdr. U. S. N., assist. Coast and Geodetic Survey; near Lieut. Trowbridge's station of 1854; in redoubt, $\phi=36°\ 36'.2$, $\lambda=121°\ 53'.8$ W. Coast and Geodetic Survey Report for 1881, App. 9.

10.—SAN FRANCISCO, CAL.

$\phi=37°\ 47'.5$ $\lambda=122°\ 27'.3$ W. of Gr.

(Presidio.)

		° ′	
1	1783.3.	12 55 E.	Deduced from 122 observations by Spanish navigators along the coast from San Blas to Nootka; see preceding investigation.
2	1792, November 20.	12 48	Capt. G. Vancouver; in $\phi=37°\ 48'$, $\lambda=122°\ 07'.5$ W. Vancouver's voyage, 1798, vol. 2, p. 27. Taken on board ship, values varying from $-12°\ 02'$ to $-13°\ 32'$. Communicated by Mr. Marcus Baker, Coast and Geodetic Survey. [Longitude defective—SCH.]
	1816, October.	16 05	Kotzebue; Kotzebue's Voyage of Discovery, 1815–'18; in $\phi=37°\ 48'.6$, $\lambda=122°\ 12'.5$ W. [Not used—SCH.]
3	1818, September 20 (O. S.).	15 00	Capt. Golovnin (V. M.); voyage around the world, St. Petersburg, 1822, vol. 2. Communicated by Mr. M. Baker.
	1824..	16 00	Kotzebue. [Not used—SCH.]
4	1827..	15 27	Beechey; Becquerel's Traité du Magnétisme, Paris, 1846.
5	1829, December 6.	14 55	Erman (A. G.); Reise um die Erde, Berlin, 1835, vol. 1.
6	1830..	14 51	Erman (A. G.); Phil. Trans. Roy. Soc., vol. 165, 1875. Sir Edw. Sabine's Cont's to Terr. Mag., No. xiv.
7	1837..	15 20	Sir Edw. Belcher; in $\phi=37°\ 48'$, $\lambda=122°\ 23'$ W. Phil. Trans. Roy. Soc., 1841.
	1837..	15 00	Du Petit Thouars; voyage of the Frigate Venus.
8	1839..	15 20	Sir Edw. Belcher; in $\phi=37°\ 48'$, $\lambda=122°\ 23'$ W. Phil. Trans. Roy. Soc., 1841.
9	1841, October,	15 30	Duflot de Mofras; exploration of Oregon, Paris, 1844; in $\phi=37°\ 48'.5$, $\lambda=122°\ 28'.4$ W.
	1842, January.	15 30	Duflot de Mofras; as above. At Fort Point, Golden Gate.
10	1849–'50.	15 40.8	Ringgold, Comdr., U. S. N.; at Alcatraz Island, harbor of San Francisco.
11	1852, February 18–28.	15 27.6	G. Davidson, asst. Coast Survey; at Presidio, astronomical station; in $\phi=37°\ 47'.5$, $\lambda=122°\ 27'.3$ W. Mean of daily maximum and minimum. Coast Survey Report for 1856, p. 229. Mean value $=-15°\ 28'.8$. See also C. and G. Survey Report for 1881, App. 9.
	1852, March 24.	15 28.8	
	1852, April 21.	15 27.8	
	1852, May 28.	15 31.1	
12	1858, June 3–8.	15 49.4	Karl Friesach; Reports Imp. Acad. of Sciences, Vienna, 1860, vol. 38; at Dupont street, near Catholic ch.; in $\phi=37°\ 47'.8$, $\lambda=122°\ 24'.0$ W.; second set of obser's corner Stockton and California sts. [Mean value $=-15°\ 52'.8$—SCH.]
	1858, June 10–12.	15 56.2 E.	

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

SAN FRANCISCO, CAL.—Continued.

		° ′	
13	1866, June 26.	16 25.5 E.	W. Harkness, Prof. U. S. N.; east side of Yerba Buena Island; in $\phi=37°$ $49'$, $\lambda=122°$ $21'$ W. Smithsonian Contributions to Knowledge, No. 239, Washington, 1873.
14	1871, December 14, 15, 16.	16 23.1	G. Davidson, asst. Coast Survey, and S. R. Throckmorton, aid; at Presidio station of 1852. Coast and Geodetic Survey Report for 1881, App. 9.
15	1872, October 26, 27, 28.	16 25.7	Reference as above.
16	1873, June 25, 26, 27.	16 25.4	Reference as above.
16	1873, August 19–23.	16 24.0	Reference as above.
16	1873, November 12–16.	16 25.4	G. Davidson and Wm. Eimbeck, assts. Coast Survey; at Presidio. Reference as above. [Mean for 1873.7 = — 16° 24′.8—SCH.]
17	1874, January 10, 12, 13, 14. 1874, February 19, 20, 21.	16 26.9	Reference as above.
18	1879, March 12–15.	16 34.0	G. Davidson and B. A. Colonna, assts. Coast Survey; at Presidio. Reference as above.
19	1880, September 25, 26.	16 28.3	H. E. Nichols, Lieut. U. S. N., asst. Coast and Geodetic Survey; at the Presidio station. Reference as above.
19	1880, November 20.	16 39.5	W. H. Dall and M. Baker, Coast and Geodetic Survey; at the Presidio station. Reference as above. [Mean value for 1880–'81 = — 16° 33′.9—SCH.]
20	1881, March 30, 31, April 1.	16 33.3	W. Eimbeck, asst. Coast and Geodetic Survey; at Presidio. Reference as above.
20	1881, April 26, 27.	16 31.9	H. E. Nichols, Lt. Comdr. U. S. N., asst. Coast and Geodetic Survey; at Presidio station. Reference as above.
20	1881, July 12, November 1.	16 32.2	H. E. Nichols, Lt. Comdr. U. S. N., asst. Coast and Geodetic Survey; at Presidio station. Reference as above.
20	1881, June 22, 23, 24, December 1, 2, 3.	16 18.2	J. S. Lawson, asst. Coast and Geodetic Survey; at Presidio station. Reference as above. [Mean of four values = — 16° 28′.9 for 1881.48—SCH.]
21	1883, June 3.	16 38.6	R. A. Marr, aid Coast and Geodetic Survey; at Presidio. MS. in archives.
22	1884, September 5–16.	16 32.3	G. Davidson, asst. Coast and Geodetic Survey, and R. A. Marr, aid; at Presidio. MS. in archives.
23	1885, August 4–12.	16 33.4	G. Davidson, asst. Coast and Geodetic Survey, and F. Morse, aid; at Presidio. MS. in archives.
24	1886, April 21–24.	16 33.1 E.	Observers, locality, and reference as above.

11.—SALT LAKE CITY, UTAH.

$\phi=40°$ $46'.1$ $\lambda=111°$ $53'.8$ W. of Gr.

(Temple Square, astronomical station.)

		° ′	
1	1850..	15 34 E.	Major W. H. Emory, U. S. A.; Amer. Acad. of Science, vol. vi, new series, 1856. In $\phi=40°$ $46'$, $\lambda=112°$ $08'$ W.
2	1866, August.	16 30	Jesse W. Fox; letter from Surveyor-General's Office, dated Aug. 29, 1866. In $\phi=40°$ $46'$, $\lambda=111°$ $54'$ W.
3	1869, May 6–15.	16 36.4 E.	G. W. Dean, asst. Coast Survey; Temple square, near astro'l station; in $\phi=$ $40°$ $46'.0$, $\lambda=111°$ $53'.8$ W. Coast and Geodetic Survey Rep. for 1881, App. 9.

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—**Continued.**

SALT LAKE CITY, UTAH—Continued.

		° ′	
4	1872..	17 01 E.	Report of Chief of Engineers, 1879, Part III, p. 2099, at Camp Douglass, near astronomical monument; in $\phi=40° 45'.8$, $\lambda=111° 50'.2$ W.
5	1878, August 15.	16 48.1	Dr. T. E. Thorpe; Proc. Roy. Soc., No. 200, 1880. East of the President's house; in $\phi=40° 46'.1$, $\lambda=111° 53'.7$ W.
	1878, October 26, 28, 29.	16 44.2	J. B. Baylor, aid Coast and Geodetic Survey; near Fourth street south and Second street east of Temple. Coast and Geodetic Survey Report for 1881, App. 9. [Mean of two determinations, $-16° 46'.2$—SCH.]
6	1881, May 12, 13, 14.	16 28.4	Wm. Eimbeck, asst. Coast and Geodetic Survey; about 25 metres S. E. of astronomical station, Temple square. Reference as above.
7	1883, November 15, 16, 17.	16 14.1	Wm. Eimbeck, asst. Coast and Geodetic Survey, and G. F. Bird, aid; station as above. MS. in archives.
8	1884, October 22, 23, 24.	16 13.6	Observer, locality, and reference as above.
9	1885, November 5–10.	16 29.3 E.	Observer, locality, and reference as above.

12.—CAPE MENDOCINO, CAL.

$\phi=40° 26'.3$ $\lambda=124° 24'.3$ W. of Gr.

(Light-House.)

		° ′	
	1579 (?)..	9 E.	Sir Francis Drake; on a map by Dudley, preserved by Petrus Koerius, dated 1646, showing the coast of New Albion, discovered by Sir F. Drake in 1579. Narrative and critical history of America, Justin Winsor, vol. 2. Boston and New York, 1886. [The compass is 1½° south of Cape Mendocino; not used—SCH.]
	1693..	2	G. F. G. Carreri, Giro del Mondo, Napoli, 1699; see also Hansteen's Magnetismus der Erde, 1819; in $\phi=40° 29'$, $\lambda=124° 29'$ W. [Result probably many degrees in error; the narrative states the pilots could give no reason for this strange result; not used—SCH.]*
1	1783.3.	14 10	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
2	1786, September 7, 8.	14 54	La Perouse (J. F. G. de); Voyage autour du monde, Paris, 1797, vol. III, pp. 302, 390. On board the Boussole, in $\phi=40° 21'$, $\lambda=124° 36'$ W., average declination $=-14° 59'$; on board the Astrolabe, about the same position, declination $=-14° 48'$. Communicated by Mr. Marcus Baker.
3	1792, April 18.	16 00	Capt. G. Vancouver; near the cape, about ten leagues from it, it bore N. 36° W. Vancouver's Voyage of Discovery, etc., 1790–'95, London 1798, vol. 1, p. 197. [This would put him in about $\phi=39° 58'$, $\lambda=124° 12'$ W., probable reduction to the Cape $-0°.25$, hence declination $=-16°.25$—SCH.]
	1792, April 19.	15 00	Same authority, vol. 1, p. 198, on board ship in $\phi=40° 03'$, $\lambda=124° 09'$ W. Cape Mendocino bore N. 2° W. four leagues from shore. [Probable reduction to Cape $-0°.20$, hence declination $-15°.20$—SCH.]
	1792, April 22.	16 00 E.	Same authority, vol. 1, p. 200. In $\phi=40° 32'$, $\lambda=124° 32'$ W. [Probable reduction to cape $+0°.10$, declination $=-15°.90$; mean of three values $=-15°.78$—SCH.]

*This navigator probably refers to False Cape Mendocino, as we may infer from his latitude. This latter cape is now called Cape Fortunas, and is in $\phi=40° 30'.5$, $\lambda=124° 22'.8$ W.—SCH.

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

CAPE MENDOCINO, CAL.—Continued.

		° ′	
4	1794, October 3.	14 00 E.	Same authority, vol. III, p. 321. In $\phi=40° 42'$, $\lambda=124° 30'$ W. [Probable reduction to cape $+0°.12$, declination $=-13°.88$—SCH.]
5	1854, April 25 to May 2.	17 04.5	G. Davidson, asst. Coast Survey; at Humboldt astronomical station in $\phi=40° 44'.7$, $\lambda=124° 12'.8$ W. Coast and Geodetic Survey Report for 1881, App. 9. [Probable reduction to cape $+0°.15$. Hence declination $=-16° 56'$—SCH.]
6	1886, April 7, 8, 9, 10.	18 00.5 E.	G. Davidson, asst. Coast and Geodetic Survey, and F. Morse, aid; near the light-house in $\phi=40° 26'.3$, $\lambda=124° 24'.3$ W. MS. in archives.

13.—VANCOUVER, WASH. T.

$\phi=45° 37'.5$ $\lambda=122° 39'.7$ W. of Gr.

(Flag-staff of Fort Vancouver.)

		° ′	
1	1788, August 14.	14 26 E.	Gray; Haswell's narrative, communicated by Asst. G. Davidson; in $\phi=45° 27'$, $\lambda=122° 19'$ W. [Probable reduction to Vancouver $-8'$, hence declination $=-14° 34'$; the weight one-half is given to this result. The formula established for stations on the coast and epoch 1783.3 would give for this place $-16° 00'$—SCH.]
2	1839--	19 22	Sir Edw. Belcher; Phil. Trans. Roy. Soc., 1841; in $\phi=45° 37'$, $\lambda=122° 36'$ W.
3	1859--	21 30	S. Garfielde, surveyor-general Washington Territory; MS. communication dated Aug. 24, 1866. [In $\phi=45° 40'$, $\lambda=122° 38'$ W.—SCH.]
4	1860--	20 05	Capt. R. W. Haig, English Commissioner of boundary survey. Phil. Trans. Roy. Soc., vol. 154, part II, 1864. In $\phi=45° 38'$, $\lambda=122° 28'$ W.
5	1881, October 26, 27.	20 53.3 E.	J. S. Lawson, asst. Coast and Geodetic Survey; south of Old Fort in $\phi=45° 37'.5$, $\lambda=122° 39'$ W. Coast and Geodetic Survey Report for 1881, App. 9.

14.—WALLULA, WASH. T.

$\phi=46° 05'$ $\lambda=118° 55'$ W. of Gr.

(Magnetic station of 1861.)

		° ′	
1	1853--	19 40 E.	Governor I. I. Stevens; North Pacific Railroad Explorations, at old Fort Walla Walla, in $\phi=46° 04'$, $\lambda=118° 48'$ W. Coast Survey Report for 1856, p. 223.
	1860--	20 30	S. Garfielde, surveyor-general of Washington Territory. In town Walla Walla, or near new Fort Walla Walla, in $\phi=46° 03'$, $\lambda=118° 20'$ W. MS. communication of Aug. 24, 1866. [Not used—SCH.]
2	1860--	20 00 E.	Capt. J. Mullan, U. S. A.; "Magnetic Variation," by J. B. Stone, New York, 1878. In $\phi=46° 03'$, $\lambda=118° 24'$ W.; in town Walla Walla, near new fort.

Group III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

WALLULA, WASH. T.—Continued.

		° ′	
3	1861..	20 30 E.	S. Garfielde, surveyor-general Washington Territory; at Wallula, or old Fort Walla Walla. [In $\phi=46°\ 05'$, $\lambda=118°\ 55'$ W.—Sch.]
	1881, September 24, 25, 26.	22 04.4	J. S. Lawson, asst. Coast and Geodetic Survey; town of Walla Walla, in $\phi=46°\ 03'.9$, $\lambda=118°\ 20'.5$ W. Coast and Geodetic Survey Report for 1881, App. 9. [Supposed to be affected by local deflection; not used—Sch.]
4	1881, September 29, 30, October 1, 2.	19 55.7 E.	J. S. Lawson, asst. Coast and Geodetic Survey, at Wallula, near and north of old fort, in $\phi=46°\ 07'$, $\lambda=118°\ 55'$ W. Reference as above.

15.—CAPE DISAPPOINTMENT, WASH. T.

$\phi=46°\ 16'.7$ $\lambda=124°\ 02'.8$ W. of Gr.

(South shore of Baker's Bay.)

		° ′	
1	1783.3.	16 23 E.	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
2	1786, September 1, 2.	18 0	La Perouse (J. F. G. de); observed on board the Boussole, Sept. 1, in $\phi=46°\ 39'$, $\lambda=124°\ 17'$ W., declination $=-18°\ 53'$; and Sept. 2, in $\phi=45°\ 57'$, $\lambda=124°\ 10'$ W., declination $=-17°\ 07'$. Voyage autour du Monde, etc., Paris, 1797, vol. iii, pp. 300, 303, 388; communicated by Mr. M. Baker.
3	1792, April 27.	18 0	Capt. G. Vancouver; on board ship; in $\phi=46°\ 14'$, $\lambda=123°\ 59'$ W., near mouth of Columbia River; Hansteen's Magnetismus der Erde, 1819.
4	1839..	19 11	Sir Edw. Belcher, in Baker's Bay, $\phi=40°\ 17'$, $\lambda=124°\ 02'$ W.; Phil. Trans. Roy. Soc., 1841.
5	1842..	20 00	Duflot de Mofras; Exploration of Oregon, Paris, 1844; at mouth of Columbia River.
6	1851, July 5–9.	20 19.1	G. Davidson, asst. Coast Survey; near beach of Baker's Bay, Cape Disappointment, in $\phi=46°\ 16'.7$, $\lambda=124°\ 02'.8$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
	1851, July 14–19.	20 45.3	Observer and reference as above; on top of cape at astronomical station, in $\phi=46°\ 16'.6$, $\lambda=124°\ 03'.0$ W. [Not used—Sch.]
7	1858..	21 00	Communication by S. Garfielde, surveyor-general Washington Territory, dated Aug. 24, 1866.
8	1873, October 24–27.	21 26.5	Wm. Eimbeck, asst. Coast Survey; near beach of Baker's Bay, in $\phi=46°\ 16'.7$, $\lambda=124°\ 02'.8$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
	1873, October 19–23.	21 46.9	Observer and reference as before; on top of cape at old astronomical station. [Not used—Sch.]
9	1881, October 14.	21 36.0 E.	H. E. Nichols, Lt. Comdr. U. S. N.; asst. Coast and Geodetic Survey; near beach.

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

OLYMPIA, WASH. T.

$\phi = 47° 02'$ λ 122° 54′ W. of Gr.

		° ′	
1	1783. 3.	16 35 E.	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
2	1853..	21 15	S. Garfielde, surveyor-general Washington Territory; in $\phi = 47° 03'$, $\lambda = 122° 54'$ W.; MS. communication to office of Aug. 24, 1866.
3	1856. 5.	20 47	Sir Edw. Sabine; Phil. Trans. Roy. Soc., 1872, communication XIII; in $\phi = 47° 03'$, $\lambda = 122° 55'$ W. [Compared with observations made at Steilacoom this value seems too small—SCH.]
4	1881, November 2, 3, 4.	21 34. 6 E.	J. S. Lawson, asst. Coast Survey; near Eleventh and Main streets, in $\phi = 47° 02'.3$, $\lambda = 122° 54'.0$ W.; Coast and Geodetic Survey Report for 1881, App. 9.
			[The above observations are insufficient to deduce a satisfactory value for secular change—SCH.]

16.—SEATTLE, DUWAMISH BAY, WASH. T.

$\phi = 47° 35'.9$ $\lambda = 122° 20'.0$ W. of Gr.

(Astronomical station of 1871.)

		° ′	
1	1783. 3.	16 45 E.	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
2	1855..	21 25	S. Garfielde, surveyor-general of Washington Terr'y. MS. communication dated Aug. 24, 1866. [In $\phi = 47° 36'$, $\lambda = 122° 20'$ W.—SCH.]
3	1871, September 27–October 3.	22 35. 4	S. R. Throckmorton, aid Coast Survey; in $\phi = 47° 35'.9$, $\lambda = 122° 20'.0$ W. Coast and Geodetic Survey Report for 1881, App. 9. [Result depends on a doubtful azimuth—SCH.]
4	1881, November 8–11.	22 02. 5 E.	J. S. Lawson, asst. Coast and Geodetic Survey; station near that of 1871. Lat. and long. as above. Coast and Geodetic Survey Report for 1881, App. 9.

17.—PORT TOWNSEND, WASH. T.

$\phi = 48° 07'.0$ $\lambda = 122° 44'.9$ W. of Gr.

(Station Point Hudson.)

		° ′	
1	1783. 3.	17 00 E.	Deduced from 122 observations of Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
	1792, May.	21 30	Capt. G. Vancouver; at Port Discovery, in $\phi = 48° 02'$, $\lambda = 122° 38'$ W. Hansteen's Magnetismus der Erde, 1819. [Apparently about 3° too great, not used—SCH.]
2	1841..	20 40	Chart by U. S. Exploring Expedition, Commander Wilkes, at Carr Point, in $\phi = 48° 03'.3$, $\lambda = 122° 50'.8$ W.
3	1856, August 17–20.	21 39. 5	G. Davidson, asst. Coast Survey; at Point Hudson, in $\phi = 48° 07'.0$, $\lambda = 122° 44'.9$ W. Coast and Geodetic Survey Report for 1881, App. 9.
4	1857..	21 54 E.	S. Garfielde, surveyor-general Washington Terr'y, at Admiralty Head, Whidbey Island, in $\phi = 48° 09'$, $\lambda = 122° 41'$ W. Letter to office, dated Aug. 24, 1866. [Reduction to Port Townsend + 8′, decl'n = — 21° 46′—SCH.]

Group III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

PORT TOWNSEND, WASH. T.—Continued.

		° ′		
	1859..	20 45	E.	Reference as above; in $\phi = 48° 07'$, $\lambda = 122° 45'$ W. [Not used—Sch.]
5	1862..	22 00		Reference as above; in $\phi = 48° 01'$, $\lambda = 121° 51'$ W., at mill.
6	1876, February.	21 59		Capt. G. H. Burden, U. S. A. Report of Chief of Engineers, U. S. A., 1876, p. 3.
7	1881, November 16, 17, 18.	21 26.9	E.	J. S. Lawson, asst. Coast and Geodetic Survey. Astronomical station of 1852 at Point Hudson, in $\phi = 48° 07'.0$, $\lambda = 122° 45'.0$ W. Coast and Geodetic Survey Report for 1881, App. 9.

18.—NEE-AH BAY, CAPE FLATTERY, WASH. T.

$\phi = 48° 21'.8$ $\lambda = 124° 38'.0$ W. of Gr.

(Astronomical station, Scarboro' Harbor.)

		° ′		
1	1783.3.	17 15	E.	Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
2	1792, April 30.	18 00		Capt. G. Vancouver; inside Cape Flattery, in $\phi = 48° 19'$, $\lambda = 123° 41'$ W. [Supposed misprint for 124° 31′—Sch.] Hansteen's Magnetismus der Erde, 1819.
3	1841..	22 30		Chart of U. S. Exploring Expedition, Commander Wilkes; at Scarborough harbor, north point of Nee-ah Island, in $\phi = 48° 21'.8$, $\lambda = 124° 38'.0$ W. [Weight ¼ assigned to this value—Sch.]
4	1852, August 17–23.	21 29.9		G. Davidson, asst. Coast Survey, and J. Rockwell, aid; at Scarboro' harbor astronomical station, in $\phi = 48° 21'.8$, $\lambda = 124° 38'.0$ W. Coast and Geodetic Survey Report for 1881, App. 9.
5	1855, August 13–18.	21 48.2		Lieut. W. P. Trowbridge, asst. Coast Survey; Nee-ah Bay, near Waaddah Island, in $\phi = 48° 22'$, $\lambda = 124° 36'.8$ W. Reference as above.
6	1881, October 11.	22 44.2	E.	H. E. Nichols, Lt. Comdr. U. S. N., asst. Coast and Geodetic Survey; near station of 1855. Reference as above.

19.—NOOTKA SOUND, VANCOUVER ISLAND.

$\phi = 49° 35'.5$ $\lambda = 126° 37'.5$ W. of Gr.

(Friendly Cove.)

		° ′		
1	1778, April 4.	19 45	E.	Capt. Cook; in Resolution Cove, $\phi = 49° 35'$, $\lambda = 126° 37'$ W. Hansteen's Magnetismus der Erde, 1819; also Encyclopædia Metropolitana, 1848. [Cook notes large local attractions on shore at Ship Cove, vol. ii, p. 338, of his Voyage to the Pacific, London, 1784; the value here given was observed on board ship—Sch.]
2	1783.3.	17 54		Deduced from 122 observations by Spanish navigators along the coast between San Blas and Nootka; see preceding investigation.
3	1786, August 25, 26.	19 47	E.	La Perouse (J. F. G. de); Voyage autour du monde, etc., Paris, 1797, vol. iii, pp. 300, 310, and 388. Observed about ten miles off shore, on board the Astrolabe, in average $\phi = 49° 39'$, and average $\lambda = 128° 39'$ W., declination = − 19° 47′. On board the Boussole in average $\phi = 49° 37'$, average $\lambda = 127° 22'$ W., declination = − 23° 14′. Communication by Mr. M. Baker, Coast and Geodetic Survey. [The observations on the Boussole not used—Sch.]

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

NOOTKA SOUND, VANCOUVER ISLAND—Continued.

		° ′	
	1791, August 16, 17, September 4.	22 30 E.	Don A. Malaspina; observed on shore; Berliner Astron. Jahrbuch, vol. 53, for 1828. Position on Sept. 4, 1791, in $\phi=49° 57'$, $\lambda=126° 19'$ W. Et. Marchand's Voyage autour du Monde, Paris, an vii, vol. 2. [Not used—SCH.]
4	1792, October.	18 22	Capt. G. Vancouver; in Nootka Sound, $\phi=49° 34'$, $\lambda=126° 28'$ W. Hansteen's Magnetismus der Erde, 1819.
5	1860..	23 47	G. H. Richards, Capt. R. N., in Friendly Cove, in $\phi=49° 35'.5$, $\lambda=126° 37'.5$ W. Vancouver Island Pilot, Admiralty, London, 1864.
6	1863..	23 05	Observer and locality as above; Admiralty chart of Nootka Sound, No. 1916, 1865. Note: Magnetic variation increasing about 2′ annually.
7	1881, September 27.	23 36.2 E.	H. E. Nichols, Lt. Comdr. U. S. N., asst. Coast and Geodetic Survey; at Friendly Cove. Coast and Geodetic Survey Report for 1881, App. 9. [Double weight has been given to this observation—SCH.]

20.—SITKA, ALASKA.

$\phi=57° 02'.9$ $\lambda=135° 19'.7$ W. of Gr.

(Parade grounds, Sitka.)

		° ′	
	1775, August 23.	22 E.	Don Bruno de Heceta; in $\phi=57° 08'$, $\lambda=140° 44'$ W.; Coast and Geodetic Survey Report for 1885, App. 7, p. 276; see also F. A. Maurelle, Journal of a voyage to N. W. coast of America, D. Barrington Miscellanies, London, 1781. [At sea, not used—SCH.]
1	1779, July 7.	23 30	San Virey and Antonio Bucareli; in $\phi=56° 13'$, $\lambda=141° 52'$ W.; Coast and Geodetic Survey Report for 1885, App. 7, p. 278.
2	1786, August 6, 7.	26 46	La Perouse (J. F. G. de); Voyage autour du monde, Paris, 1797, vol. iii, pp. 296, 299, 386; mean of four determinations, a few leagues off shore. On board the Boussole, declination $=28° 28'$ E., in average $\phi=56° 54'$ and average $\lambda=135° 26'$ W.; on board the Astrolabe, about the same positions, declination $=25° 04'$ E. [Mean declination $=-26° 46'$ used—SCH.] Observations communicated by Mr. Marcus Baker, attached to the Computing Division at the Survey Office in July, 1879.
3	1787, June.	24 0	Capt. G. Dixon; Voyage around the world, London, 1789, at anchor near White's Point, $\phi=57° 03'$, $\lambda=135° 38'$ W. From compass bearings. Communicated by Mr. M. Baker.
4	1791, August 8, 11, 21.	27 46	Capt. E. Marchand; Voyage around the world, London, 1801, two volumes. Mean of three values given in vol. ii. One mile north of Dixon's station, in $\phi=57° 04'$, $\lambda=135° 39'$ W. (In volume i the observer gives the declination $=-28° 45'$.) Communicated by Mr. M. Baker.
5	1804, August 20.	26 45	Capt. U. Lisiansky; Voyage around the world, London, 1814. In $\phi=57° 03'$, $\lambda=135° 30'$ W.
6	1818, July.	27 15	Capt. V. M. Golovnin; Voyage around the world, St. Petersburg, 1822, vol. ii. Mean of several observations between $-24°$ and $-30\frac{1}{2}°$. In $\phi=57° 02'.8$, $\lambda=135° 06'.6$ W. Communicated by Mr. M. Baker.
7	1824, August.	27 30 E.	Capt. Otto von Kotzebue; New voyage around the world, 1823–26, London, 1830, vol. ii, pp. 66, 77; see also Becquerel's Traité du Magnétisme, Paris, 1846. In $\phi=57° 02'.9$, $\lambda=135° 33'.3$ W.

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

SITKA, ALASKA—Continued.

		° ′	
8	1827.5.	28 50 E.	Capt. F. P. Lütke. Gen'l Sir Edw. Sabine's Conts. to Terr. Mag., No. xiii, Phil. Trans. Roy. Soc., 1872. In $\phi = 57° 03'$, $\lambda = 135° 23'$ W.
9	1829, November 10.	28 18.8	Ad. Erman; Reise um die Welt, Berlin, 1835, vols. i and ii; a careful determination on shore, in a place behind the church, in $\phi = 57° 02'.7$, $\lambda = 135° 25'.5$ W.
10	1837, September 12–16.	27 42	Sir Edw. Belcher; a careful determination on shore near the Governor's house, in $\phi = 57° 03'$, $\lambda = 135° 26'$ W. Sir Edw. Sabine; in Phil. Trans. Roy. Soc., 1841, part i.
	1839, July 15–19.	29 32.5	Sir Edw. Belcher; a careful determination at summer-house in the Governor's garden, in $\phi = 57° 03'$, $\lambda = 135° 22'$ W. Sir Edw. Sabine; in Phil. Trans. Roy. Soc., 1843, part i. [Mean of these two values, or—28° 37', used for epoch 1838.6—SCH.]
11	1842, every month, except January, February, and October.	28 32.4	At magnetic observatory on Japonski Island, founded in 1842. Hourly observations. In $\phi = 57° 02.'9$, $\lambda = 135° 20'.1$ W. Annuaire Mét. et Mag. du Corps des Mines de Russie, St. Pétersbourg, 184– to 184–.*
12	1843, January to December.	28 54.0	
13	1844, January to December.	28 57.3	
14	1845, January to December.	29 00.0	
15	1847, May to December.	28 58.9	At magnetic observatory on Japonski Island. Annales de l'observ. phys. central de Russie, St. Pétersbourg, 184– to 185–.
16	1848, January to December.	29 04.5	
17	1849, January, February, March.	29 03.6	
18	1850, January to December.	28 50.3	
	1851.0.	29 14	Capt. Richard Collinson; MS. in Brit. Hyd. Office. Sir Edw. Sabine in Phil. Trans. Roy. Soc., 1872; Conts. to Terr. Mag., No. xiii. [Not used—SCH.]
19	1851, whole year.	28 53.1	See differential observations at magnetic observatory, Japonski Island; Compte Rendu of the Central Physical Observatory of Russia, 1851 to 1864. In 1851–'52–'56 observations during 17 hours each day.
20	1852, January to July, November, and December.	28 48.5	
21	1856..	28 58.6	
22	1857, whole year.	29 07.2	Differential observations as above; in 1857–'58–'59–'60–'61–'63–'64 observations during 19 hours each day.
23	1858, whole year.	29 10.5	
24	1859, whole year.	29 06.1	
25	1860, whole year.	29 07.9	
26	1861..	29 04.1	
27	1862, whole year.	29 00.9	Hourly observations in 1862.
28	1863..	29 03.3	
29	1864..	29 04.2	[Mr. Marcus Baker discussed the magnetic observations at Japonski Island made between 1850 and 1864 incl., and as there was no absolute determination for this period, he based his annual mean values on the computed value resulting from my expression of the secular change at Sitka, given in the preceding edition; thus the differential scale reading 396.0 for 1857.5 corresponds to the declination 29° 07'.2 E., March, 1882—SCH.]
30	1867, August 17, 18, 19, 20.	28 49 E.	A. T. Mosman, asst. Coast Survey; at old Russian observatory on Japonski Island, harbor of Sitka, in $\phi = 57° 02'.9$, $\lambda = 135° 20'.1$ W. Coast Pilot of Alaska by the U. S. Coast Survey, 1869, p. 120.

*For the collection of the values Nos. 11 to 29 incl., I am indebted to Mr. Marcus Baker, of the Coast Survey, Computing Division, 1879. He discussed the differential hourly observations made at the magnetic observatory between 1842 and 1849, basing the annual means upon the absolute determinations of Jan. 4, 1843, when D = 28° 48'.9 E., and of March 4, 1843, when D = 28° 57'.3 E. The first value corresponded to scale value 419.3, the second to 432.4 divisions of the differential declinometer—SCH.

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

SITKA, ALASKA—Continued.

		° ′	
31	1874, May 4, 5.	28 59.5 E.	M. Baker, U. S. Coast Survey, W. H. Dall, asst. in charge of party; station on parade ground, in $\phi=57° 02'.9$, $\lambda=135° 19'.7$ W. Coast and Geodetic Survey Report for 1881, App. 9.
32	1876, January 15 to March 20.	28 20.5	Capt. J. B. Campbell and Lt. W. R. Quinan, U. S. A.; Report of Chief of Engineers 1876, part 3, p. 751.
33	1879, April.	28 54	Lieut. J. E. Craig, U. S. S. Alaska; Report to Capt. G. Brown, U. S. N., May 7, 1879, at station of 1874 on parade ground.
34	1880, May 17, 18.	29 04.8	M. Baker and W. H. Dall, U. S. Coast and Geodetic Survey; near old Russian observatory, Japonski Island, in $\phi=57° 02'.9$, $\lambda=135° 20'.3$ W. Coast and Geodetic Survey Report for 1881, App. 9.
35	1881, September 15, 16.	29 11.2 E.	H. E. Nichols, Lt. Comdr. U. S. N., asst. Coast and Geodetic Survey; on Japonski Island, station of 1880. Reference as above.

21.—PORT MULGRAVE, YAKUTAT BAY, ALASKA.

$\phi=59° 33'.7$ $\lambda=139° 45'.9$ W. of Gr.

		° ′	
1	1778, May 6.	23 10 E.	Capt. J. Cook; Voyage to the Pacific Ocean, London, 1784, vol. iii, p. 506. May 6, at sea, off Dry Bank, in $\phi=59° 08'$, $\lambda=139° 41'$ W.
	1778, May 7.	24 26	May 7, at sea, near coast south of Mt. St. Elias, in $\phi=59° 27'.5$, $\lambda=140° 53'$ W. Communicated by Mr. M. Baker, Coast and Geodetic Survey. [Taking mean values we have for $\phi=59° 18'$, $\lambda=140° 17'$ W., the declination $=-23°.80$ for 1778.3; the weight one-half is given to this value—SCH.]
2	1787, May.	26 00	Capt. G. Dixon; Voyage round the World, London, 1789.
3	1791, July 1.	26 40	Don A. Malaspina; Bode's Berliner Jahrbuch for 1828; also Espinoza Memorias, 2 vols., Madrid, 1809. On shore in $\phi=59° 33'.7$, $\lambda=139° 46'.3$ W.
4	1794, July.	26 00	Capt. G. Vancouver; A Voyage of Discovery, 1790–'95, London, 1798. At Port Mulgrave, Lieut. Puget, observer, with ship's compass. Communicated by Mr. M. Baker.
5	1802 (about).	29 00	Old Russian chart without date or author; at New Russia Harbor, settled 1795 and destroyed 1803; in $\phi=59° 31'$, $\lambda=139° 36'.5$ W. Communicated by Mr. M. Baker.
6	1823..	30 30	Lieut. Khromchenko, on Russian Hydro'c Chart, No. 1378; at end of spit, in $\phi=59° 33'.6$, $\lambda=139° 46'.5$ W.
7	1874, May 22.	29 58.3	M. Baker, U. S. Coast Survey, W. H. Dall, chief of party. Coast and Geodetic Survey Report for 1881, App. 9.
8	1880, June 24.	29 59.8 E.	Observer and reference as above. At Yakutat Bay.

Group III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

22.—PORT ETCHES, PRINCE WILLIAM SOUND, ALASKA.

$\phi = 60° 20'.7$ $\lambda = 146° 37'.6$ W. of Gr.

(Astronomical station of 1874.)

		° ′	
1	1778, May 19.	23 37 E.	Capt. J. Cook, Voyage to the Pacific Ocean, 3 vols., London, 1784, vol. iii, p. 507. Communicated by Mr. M. Baker, Coast and Geodetic Survey.
2	1787, May.	26 00	Portlock; Voyage, &c., London, 1789; at Chalmer's Harbor, in $\phi = 60° 17'$, $\lambda = 147° 27'$ W. Communicated by Mr. M. Baker.
	1787, May and July.	26 30	Observer and reference as above. At Port Etches, Garden Cove, in $\phi = 60° 20'.5$, $\lambda = 146° 46'$ W.; maps, pp. 215 and 216. Communicated by Mr. M. Baker.
	1787..	27 00	James Johnstone, Dalrymple's charts, at Cape Hinchinbrock, in $\phi = 60° 18'$, $\lambda = 147° 01'$ W. Comm'd by Mr. M. Baker. [Not used—Sch.]
3	1788, May 17.	25 00	Don Estaban Martinez, in the Princessa. In $\phi = 60° 10'$, $\lambda = 147° 35'$ W. Coast and Geodetic Survey Report for 1885, App. 7, p. 281.
4	1790..	26 28	Nuchek, Constantine Redoubt. Sarycheff, old Russian chart without date or number; in $\phi = 60° 18'$, $\lambda = 146° 32'$ W. Communicated by Mr. M. Baker.
	1790, May 23.	26 00	Fidalgo, in the packet Philipino. In $\phi = 60° 12'$, $\lambda = 146° 31'$ W. Coast and Geodetic Survey Report for 1885, App. 7, p. 283. [Mean value = —26° 14′ used in discussion—Sch.]
	1790, July 30.	28 30	Commodore J. Billings; M. Sauer, Account of a Geographical and Astronomical Expedition, London, 1802, p. 200. Communicated by Mr. M. Baker. [Not used—Sch.]
5	1794, June.	28 30	Capt. G. Vancouver; Voyage round the World, London, 1798, vol. iii, p. 188; at Port Chalmers, in $\phi = 60° 16'$, $\lambda = 146° 38'$ W. Observed 30 sets with 4 compasses, ranging from —26° 50′ to —30° 09′. Communicated by Mr. M. Baker.
6	1810 (?)	28 07.5	Nuchek; Sarycheff, old Russian chart No. xvii; in $\phi = 60° 17'.5$, $\lambda = 147° 00'$ W. Communicated by Mr. M. Baker.
7	1830..	31 38	Nuchek, Constantine Redoubt. Chernoff, Russian Hydr'c Chart No. 1378, published in 1847. In $\phi = 60° 20'$, $\lambda = 146° 32'.5$ W.
8	1837, Aug. 27.	31 38	Sir Edw. Belcher, on beach near Phipp's Point, Port Etches. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., 1843, part 2, and Contributions xiii, 1872; in $\phi = 60° 21'$, $\lambda = 146° 41'$ W.
9	1874, May 31.	29 09.8 E.	Marcus Baker, U. S. Coast Survey (W. H. Dall, chief of party); at Port Etches, on beach near Phipp's Point. Geographical position as in heading. Coast and Geodetic Survey Report for 1881, App. 9.

23.—ST. PAUL, KADIAK ISLAND, ALASKA.

$\phi = 57° 48'.0$ $\lambda = 152° 21'.3$ W. of Gr.

(Astronomical Station of 1867.)

		° ′	
1	1778, May 21.	23 42 E.	Capt. J. Cook; Voyage to the Pacific Ocean, London, 1784, vol. ii, pp. 507–'8. At sea off Pye Islands in $\phi = 59° 30'.3$, $\lambda = 149° 54'$ W.
	1778, June 13.	20 31 E.	Same observer and reference; at sea off S. W. end of Kadiak in $\phi = 56° 49'$, $\lambda = 154° 20'$ W. Communicated by Mr. M. Baker, C. and G. Survey. [Taking mean values we have for $\phi = 58° 10'$, $\lambda = 152° 07'$ W., the value —22° 06′ for epoch 1778.4. The weight one-half was given to this result—Sch.]

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

ST. PAUL, KADIAK ISLAND, ALASKA—Continued.

		° ′	
	1779, August 9.	27 0 E.	San Virey and Antonio Bucareli. At sea in $\phi = 57° 59'$, $\lambda = 152° 07'$ W. Coast and Geodetic Survey Report for 1885, App. 7, p. 278. [Not used —SCH.]
2	1790..	25 30	Sarycheff, old Russian chart, no date.
	1790, July 10.	22 10	Fidalgo, in packet Philipino; in $\phi = 58° 10'$, $\lambda = 152° 07'$ W. Camacho Island in sight. Coast and Geodetic Survey Report for 1885, App. 7, p. 283. [Not used—SCH.]
3	1804, August 16.	26 07	U. Lisiansky; Voyage, etc., London, 1814, p. 365.
4	1808..	26 00	Russian Naval Officer; old Russian chart, sheet No. xvi. In $\phi = 57° 47'.2$, $\lambda = 152° 18'.3$ W. Communicated by Mr. M. Baker. [The mean declination = $-25° 45'$ will be used in the discussion—SCH.]
	1808..	25 30	
5	1818, July 19.	26 30	Golovnin (V. M.); Voyage, etc., St. Petersburg, 1822, vol. 2, p. 59. At St. Paul Harbor in front of Governor's house on hill, in $\phi = 57° 47'.2$, $\lambda = 152° 18'.3$ W. Communicated by Mr. M. Baker.
6	1834..	28 38	Murasheff; at St. Paul's Harbor. Russian Hydr'c chart, No. 1425. Communicated by Mr. M. Baker.
7	1839, July.	26 43	Sir Edw. Belcher, near Cape Greville, in $\phi = 57° 20'$, $\lambda = 152° 51'$ W. Phil. Trans. Roy. Soc., 1843, part ii.
8	1845 (?)	27 00	Vasilieff; Tebenkoff's Atlas, xxiii. St. Paul's Harbor. Communicated by Mr. M. Baker.
9	1867, August 28, 29.	26 05	A. T. Mosman, asst. Coast Survey; Harbor of St. Paul at astronomical station on steep rocky bluff about 1½ miles east of village, in $\phi = 57° 48'.0$, $\lambda = 152° 21'.4$ W. Coast and Geodetic Survey Report for 1881, App. 9.
10	1874, June 7.	25 22	Marcus Baker and W. H. Dall, U. S. Coast Survey; reference as above.
11	1880, July 9.	25 09.2 E.	Observers and reference as above; at Chagafka Cove, harbor of St. Paul.

24.—UNALASHKA, CAPTAIN'S AND ILIULIUK HARBORS.

$\phi = 53° 52'.6$ $\lambda = 166° 31'.5$ W. of Gr.

(Greek Church, Iliuliuk Village.)

		° ′	
	1778, October 12.	19 59.2 E.	Capt. J. Cook; Voyage to the Pacific Ocean, London, 1784. Position on shore of Samganuda harbor; in $\phi = 53° 55'$, $\lambda = 166° 30'$ W. [Not used—SCH.]
	1789..	19 30	John Henry Cox; Dalrymple's charts. Muscle Cove in $\phi = 53° 50'$. Communicated by Mr. Marcus Baker, Computing Division, Coast Survey, 1879. [Not used—SCH.]
1	1790, June 4–13.	19 35	Commodore J. Billings; M. Sauer, An account of a geographical and astronomical expedition to the northern parts of Russia, London, 1802. On shore of Beaver Bay in $\phi = 53° 56'$, $\lambda = 165° 40'$ W. Communicated by Mr. M. Baker. [Weight one-half assigned in discussion—SCH.]
2	1792..	19 00	Sarycheff; old Russian chart, no date, year doubtful; at Iliuliuk in $\phi = 53° 57'$, $\lambda = 166° 32'$ W. Communicated by Mr. W. H. Dall, asst. Coast Survey, Nov., 1873.
3	1817, June.	19 24 E.	Otto von Kotzebue; Voyage of discovery into the South Sea, London, 1821. Iliuliuk Village, in $\phi = 53° 52'.4$, $\lambda = 166° 31'.9$ W. Communicated by Messrs. Dall and Baker, U. S. Coast Survey.

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

UNALASHKA, CAPTAIN'S AND ILIULIUK HARBORS—Continued.

		° ′	
4	1827, August 11.	19 50 E.	Capt. F. P. Lütke; Lenz in Mem. St. Pet. Acad. of Sci., vi série Math. et Phy. Sc., vol. i, 1838. In $\phi=53°\ 54'$, $\lambda=166°\ 30'$ W. Communicated by Mr. M. Baker.
	1829.0	19 54	Capt. F. P. Lütke; Gen. Sabine, in Phil. Trans. Roy. Soc., vol. 162, London, 1872. [Supposed to refer to the same observation as above; not used—SCH.]
5	1831..	19 30	Vasilieff (?); at sea, north of Akutan. Russian Hydrogr. chart, No. 1379, 1847. In $\phi=54°.4$, $\lambda=166°.0$ W. Communicated by Mr. M. Baker.
	1848..	19 30.5	Russian Hydrographic Office, chart 8. [Supposed to refer to preceding observation; not used—SCH.]
6	1849..	20 00	Tebenkoff's Atlas, chart No. xxv, near church at Iliuliuk in $\phi=53°\ 52'$, $\lambda=166°\ 25'$ W.
7	1867, September 8, 9.	19 47.4	A. T. Mosman, asst. Coast Survey (G. Davidson, chief of party); on shore at Captain's Harbor at Spithead, in $\phi=53°\ 53'.9$, $\lambda=166°\ 30'.4$ W. Coast and Geodetic Survey Report for 1881, App. 9.
8	1870..	19 45	Kadin; MS. chart of Iliuliuk and Captain's Harbor. Communicated by Mr. W. H. Dall.
	1871, November 11.	18 36	Dr. W. H. Dall, observer; Amaknak Island, opposite village. [Not used—SCH.]
9	1873, May 26, 27.	19 07.2	Dr. W. H. Dall, observer; near church of Iliuliuk; in $\phi=53°\ 52'.6$, $\lambda=166°\ 31'.6$ W.
	1873, September 17, 18, 19.	18 59.7	Mr. M. Baker, observer; Amaknak Island, off village in $\phi=53°\ 52'.9$, $\lambda=166°\ 31'.7$ W. Coast and Geodetic Survey Report for 1881, App. 9. [Weighted mean declination—19° 03′.2 used in discussion—SCH.]
10	1874, September 15.	18 42.8	Mr. M. Baker, observer. Reference as above.
11	1880, July 28, 29.	18 38.0	Messrs. Baker and Dall, Coast and Geodetic Survey, Iliuliuk Harbor; position as in 1873, Amaknak Isd. Reference as before.
12	1883, September 20, 21.	18 42.8 E.	Mr. R. A. Marr, aid, Coast and Geodetic Survey; at spit in Captain's Harbor. MS. in office.

25.—PORT CLARENCE, ALASKA.

$\phi=65°\ 16'$ $\lambda=166°\ 50'$ W. of Gr.

(Point Spencer.)

		° ′	
1	1827.5.	26 55 E.	Capt. Beechey; Port Clarence and Grantley Bay, in $\phi=65°\ 17'$, $\lambda=166°\ 19'$ W. Sir Edw. Sabine, in Phil. Trans. Roy. Soc., Contribution xiii; 1872.
2	1850.5	26 26	Captain Kellett. Reference as above.
3	1854.5.	26 00	Captain Maguire. Reference as above.
4	1879, July.	23 01.3	Aug. Wykander; Nordenskiold in the "Vega." Communicated by Mr. W. H. Dall.
5	1880, September 8.	22 45 E.	Mr. M. Baker, Coast and Geodetic Survey (W. H. Dall, chief of party); at Port Clarence, near Point Spencer, in $\phi=65°\ 16'.1$, $\lambda=166°\ 50'.6$ W. Coast and Geodetic Survey Report for 1881, App. 9.

Group III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

26.—CHAMISSO ISLAND, KOTZEBUE SOUND, ALASKA.

$\phi=66° 13'$ $\lambda=161° 49'$ W. of Gr.

		° ′	
1	1826, August.	31 24.3 E.	Capt. F. W. Beechey; Beechey's Narrative of a Voyage to the Pacific 1825–'28, London, 1831. Communicated by Mr. M. Baker.
	1826.5.	31 10	Brit. Admiralty chart, No. 593. Communicated by Mr. M. Baker.
	1826.5.	28 53	Capt. F. W. Beechey. Reference as above. Sir Edw. Sabine's Cont's, xiii, Phil. Trans. Roy. Soc., 1872. [Not used—Sch.]
2	1849.5.	30 26	Capt. H. Kellett. Reference as above. In $\phi=66° 16'$, $\lambda=161° 48'$ W.
3	1880, August 31.	26 49 E.	Mr. M. Baker, Coast and Geodetic Survey (W. H. Dall, in charge of party); at Chamisso Harbor; position $\phi=66° 13'.3$, $\lambda=161° 48'.7$ W.

27.—PETROPAVLOVSK, KAMTCHATKA, SIBERIA.

$\phi=53° 01'$ $\lambda=158° 43'$ E. of Gr.

		° ′	
1	1779, June.	6 18.7 E.	Capt. J. King; A voyage to the Pacific Ocean, London, 1784. West side of village, in $\phi=53° 00'.6$, $\lambda=158° 43'.3$ E.
2	1792..	6 00	G. Sarycheff; F. P. Lütke's Voyage around the world, St. Petersburg, 1835.
3	1804, September.	5 20	A. J. von Krusenstern; Voyage round the world, London, 1813. On the spot on which the village stands, in $\phi=53° 00'.2$, $\lambda=158° 47'.7$ E.
	1804, September.	5 39	Observer and reference as above. On Avatcha Bay. [Mean value = —5°.49 used in discussion—Sch.]
	1809, June 23, July 23.	7 21	Capt. Hagemeister; mean value by two compasses. A. G. Erman, Reise um die Erde, Berlin, 1835, vol. ii. Communicated by Mr. M. Baker. [Not used—Sch.]
	1825.5.	4 13	Gen. Sir Edw. Sabine's Cont's to Terr. Mag., No. xiii, in Phil. Trans. Roy. Soc., 1872; in $\phi=53° 00'$, $\lambda=158° 40'$ E. [This is supposed to refer to Capt. Beechey's observation of 1827; not used—Sch.]
4	1827, July.	4 13.3	Capt. F. W. Beechey; Narrative of a Voyage to the Pacific, 1825–'28, London, 1831; mean of 9 determinations, in $\phi=53° 01'$, $\lambda=158° 43'.5$ E.
	1827, September 30.	3 43	Capt. F. P. Lütke; Lenz in Mem. St. Peters. Acad. Sc., vi, vol. i, 1838; in $\phi=53° 01'$, $\lambda=158° 44'$ E.
	1827, September 30.	4 05.8	A. G. Erman, Reise um die Erde, Berlin, 1835. In $\phi=53° 00'.5$, $\lambda=158° 40'$ E. [The mean of the three determinations is used giving the middle one the weight one-half, hence for 1827.6 the declination = —4°.07—Sch.]
	1829.5.	4 04	Gen. Sir Edw. Sabine's Cont's to Terr. Mag., in Phil. Trans. Roy. Soc, 1872. [This is supposed to refer to Erman's value of 1827; not used—Sch.]
5	1837, September 4.	3 27	Du Petit Thouars; Voyage autour du monde, Paris, 1843. In front of Auchard's house, in $\phi=53° 01'$, $\lambda=158° 43'$ E.
6	1849.5.	2 37	Capt. H. Kellett; Gen. Sir Edw. Sabine in Phil. Trans. Roy. Soc., vol. 162, London, 1872.
7	1854, July.	3 40	Frigate Aurora; Compte-rendu annuel de l'Observatoire Phys. Cent. de Russie, année 1854; St. Pétersbourg, 1855. In $\phi=53° 00'$, $\lambda=158° 43'.5$ E. [Weight one-half assigned to this value—Sch.]
	1856, October.	3 24 E.	Admiralty chart, No. 2460; Position of Petropavlovsk in Ency. Brit., 7th edition, $\phi=53° 01'$, $\lambda=158° 43'$ E. [Supposed to be a computed value; not used—Sch.]

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—**Continued.**

PETROPAVLOVSK, KAMTCHATKA, SIBERIA—Continued.

		° ′	
8	1866..	1 25.1 E.	K. S. Staritzky; Onazevich's collection of observations made during hydrographic explorations in the Pacific, 1874–'77; St. Petersburg, 1878.
9	1876, June 11, 13, September 15.	1 09 E.	M. L. Onazevich; Reference as above.

N. B.—This important Asiatic station was included in the discussion on account of its proximity to the Western Aleutian or Rat Islands, and as affording the means for connecting the law of secular change with that found to prevail over Siberia. For information No. 3, part of 4 and of Nos. 5, 7, and 9, I am indebted to Mr. Marcus Baker, temporarily (1879) attached to the Computing Division of the Coast and Geodetic Survey Office.

The following two stations on the Sandwich Islands, which were first introduced in the third edition of the paper on the secular change, are here retained, but *without* giving for them an analytical expression of the law of change. This was thought to be the proper course to pursue in view of the uncertainty now attaching to the former values in consequence of later and important information bearing on the subject.

In a letter addressed to me by Curtis J. Lyons, assistant Government Survey, dated Honolulu, January 9, 1884, Mr. Lyons expresses his conviction that from 1850 to 1884 the secular variation was *increasing* the easterly declination prevailing over the Sandwich Islands, and cites his experience on Hawaii, viz: "From a number of compass bearings observed by me in 1853 when compared with the respective bearings taken by the same compass and the same observer in 1872–'73, the increase of declination was 40′, hence annual increase 2′.0" Again, in 1873, Mr. Lyons made careful notes of a magnetic bearing of a base line in Oahu and repeated the same with the same instrument in 1884 and found an increase of about 20′, hence annual increase 1′.8. He also states that he knows the spot where Commander Wilkes' observatory stood at Honolulu in 1841, and that the old site is now included in the palace yard; at this place he finds the declination in 1884 to be 9° 30′ E., hence annual increase 1′.7.

If it thus be a fact that from about the middle of this century to the present time the east declination on the Sandwich Islands has been on the increase, as believed by Mr. Lyons, the explanation might be found in the presence or obtrusion of a secondary wave of sufficient range to have temporarily overpowered and concealed the ordinary effect of the primary wave of secular motion. There certainly was indicated by the observations an increase of east declination from the earliest times for which we have here record up to the year 1832, some years more or less, when apparently a maximum was reached; this last feature it would seem we have now to give up and await further development before we can be certain of our deductions.

In a second letter to me dated Honolulu April 23, 1884, Mr. Lyons gives further evidence supporting his former statements by fresh observational evidence of direct measures, and gives as his result that the annual increase of easterly declination between 1871 and 1884 was about $\frac{1}{3}$ (1′.9 +2′.2 +1′.5) or 1′.9 very nearly.

28.—KAILUA (KAIRUA), HILO AND KEALAKEKUA (KARAKAKOA) BAYS, ISLAND OF HAWAII (OWHYHEE), SANDWICH ISLANDS.

$\phi = +19° \ 37'$ $\lambda = 156° \ 01'$ W. of Gr.

(Kailua Bay.)

		° ′	
1	1779..	8 06 E.	Capt. J. Cook; in $\phi = 19° \ 28'$, $\lambda = 156° \ 00'$ W. P. Barlow in Encycl. Metropol., London, 1848.
2	1791, October 4, 8.	8 02 E.	Capt. Etienne Marchand; west of Hawaii. Voyage autour du Monde, Paris, an vii, vol. 2. On Oct. 4, declination = 8° 00′ E., in $\phi = 19° \ 13'$, $\lambda = 154° \ 34'$ W.; on Oct. 8, decl'n = 8° 05′ E., in $\phi = 19° \ 19'$, $\lambda = 157° \ 22'$ W.

Group III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—**Continued.**

KAILUA (KAIRUA), HILO AND KEALAKEKUA (KARAKAKOA) BAYS, ISLAND OF HAWAII (OWHYHEE), SANDWICH ISLANDS—Continued.

		° ′		
3	1793, March.	7 47	E.	Capt. G. Vancouver; A Voyage of Discovery, etc., London, 1804. Mean of 3 compasses on ship and on shore, in $\phi = 19° 28'.2$, $\lambda = 156° 02'.2$ W. See also Encycl. Metropol., London, 1848.
4	1796..	8 15		Lieut. W. R. Broughton; Encycl. Metropol., London, 1848. [Second value not used—Sch.]
	1796..	9 12		
5	1818, October.	7 30		Capt. V. M. Golovnin, at Kairua Bay. Voyage around the world, St. Petersburg, 1822, vol. 2.
6	1819..	9 50		Capt. Freycinet; at Kawaihae, in $\phi = 20°.5$, northwest Hawaii.
	1824..	10 14		Byron; Island of Owhyhee in $\phi = 19° 43'$, $\lambda = 156° 10'$ W. Gen. Sir Edw. Sabine's Cont's to Terr. Mag., No. xiv; in Phil. Trans. Roy. Soc., vol. 165, pt. i, 1875. [Not used—Sch.]
7	1825..	8 51		Byron; at Hilo. Communicated by W. D. Alexander, supt. Hawaiian Government Survey, letter of Dec. 11, 1877.
	1836..	7 43		Voyage de la Vénus, Paris, 1841. Position and reference as for the value for 1824, above. [Not used.—Sch.]
8	1841..	8 50		Commander C. Wilkes, U. S. N.; at Hilo. Communicated by Mr. W. D. Alexander, Supt. Hawaiian Survey.
9	1845, March 8.	9 27		U. S. Hydrographic Office. U. S. S. Brandywine at sea, in $\phi = 19° 35'$, $\lambda = 158° 14'$ W. [Reduction to Kailua $+6'$, hence declination $-9° 21'$—Sch.]
10	1853..	8 15		C. J. Lyons, asst. Hawaiian Government Survey; on shore at Kawaihae. Comm'd by Mr. W. D. Alexander, supt. Haw. Survey.
11	1875, August 18.	7 34		H. M. S. Challenger; Hilo, on Cocoanut Island, in $\phi = 19° 43'.9$, $\lambda = 155° 04'.0$ W. Rock consists of lava, and very magnetic. Voyage of H. M. S. Challenger, Narrative, vol. ii, London, 1882.
12	1877..	8 10		Observer, C. J. Lyons; in Hamakua and North Hilo, N. E. coast of Hawaii. Comm'd as for No. 10. [10′ may be subtracted to refer to latitudes of Hilo and Kailua, hence decl'n $-8°.0$—Sch.]
13	1884.0	8 30	E.	Letter of C. J. Lyons, dated Honolulu, Jan. 9, 1884; consideredby him as the best value for this date, as based upon actual survey.

29.—HONOLULU, ISLAND OF OAHU (WOAHOO), SANDWICH ISLANDS.

$\phi = +21° 18'.2$ $\lambda = 157° 55'.0$ W. of Gr.

(Fort near town.)

		° ′		
1	1792, March.	7 50	E.	Capt. G. Vancouver; observed on board ship, at anchor in Whyteete Bay, in $=21° 16'.8$, $\lambda = 157° 50'.4$ W. Voyage around the world, London, 1798, vol. i. Communicated by Mr. M. Baker, Coast and Geodetic Survey.
	1793..	5 52		Capt. G. Vancouver; at Waikiki, south of Honolulu. Communicated by Mr. W. D. Alexander, supt. Hawaiian Government Survey, in letter dated Mikawao, Maui, Dec. 11, 1877. [Not used—Sch.]
2	1796, February.	9 41	E.	Lieut. W. R. Broughton; Whyteete Bay, in $\phi = 21° 18'$, $\lambda = 157° 59'.5$ W. A Voyage of Discovery, London, 1804. Communicated by Mr. M. Baker.

Group III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—Continued.

HONOLULU, ISLAND OF OAHU (WOAHOO), SANDWICH ISLANDS—Continued.

		° ′		
	1816..	10 57	E.	Kotzebue; at Honolulu. Communicated by Mr. W. D. Alexander, supt. H. S. [Not used—Sch.]
3	1819..	10 24		Capt. Freycinet; at Honolulu. Reference as above.
4	1824–'25.	9 52		Byron; from L. S. Kaemtz's MSS. Oahu Island, in $\phi=21° 17'$, $\lambda=158° 00'$ W. Gen. Sir Edw. Sabine's Cont's to Terr. Mag., No. xiv. Phil. Trans. Roy. Soc., vol. 165, pt. i, 1875.
5	1827..	10 26		Capt. Beechey; position and reference as above.
6	1836..	10 11		Voyage de la Bonite, Paris, 1842. Honolulu, in $\phi=21° 19'$, $\lambda=157° 48'$ W. Reference to Phil. Trans. as above.
7	1837..	10 00		Voyage de la Vénus, Paris, 1841. Position and reference as above.
	1837..	10 39		Capt. Beechey.. } On Oahu Island. Reference as above. [Mean value for 1837.5, = — 10°.32—Sch.]
8	1838..	10 39		Capt. Belcher.. }
9	1840..	9 17		Berghaus; from L. S. Kaemtz' MSS.; at Honolulu.
	1841..	8 15		Commander C. Wilkes, U. S. N.; at Honolulu. Communicated by Mr. W. D. Alexander, supt. H. S. Not used—Sch.]
10	1845, January 25.	10 10		U. S. Hydrographic Office; U. S. S. Brandywine, at sea, in $\phi=21° 54'$, $\lambda=157° 05'$ W. [Reduction to Honolulu + 5′, hence declination = — 10° 05′—Sch.]
11	1852..	9 10		Capt. Collinson, MS. in Brit. Hydr. Office. At Honolulu. Gen. Sir. Edw. Sabine, in Phil. Trans. Roy. Soc., vol. 165, p. i, 1875.
12	1859, January, February, and March.	9 42		Karl Friesach; Memoirs of the Imperial Academy of Sciences, Vienna, vols. xxix to xliv. In =21° 18′.6, =157° 48′.9 W.
	1867, August.	11 15		Capt. W. Reynolds, U. S. N., in the Lackawanna; Chart No. 6. Wharf near custom house, in ϕ = 21° 18′.2, =157° 50′.1 W. [Not used—Sch.]
13	1871..	9 36		C. J. Lyons, asst. Government Survey; north side of entrance to Honolulu harbor. Comm'd by W. D. Alexander, supt. H. G. S., letter of Dec. 11, 1877.
14	1872..	9 18		Observer and reference as above. On the south side of entrance, at Fisherman's Point.
15	1873..	9 25		Observer as before, in Punchbowl street, in $\phi=21° 18'$, $\lambda=157° 52'$ W. Comm'd by C. J. Lyons, letters of Jan. 9 and Apr. 23, 1884.
	1873..	9 50		Observer and reference as before. West base Oahu triangulation, Honolulu. [Mean value for 1873.5, = — 9°.63—Sch.]
16	1875..	9 16		W. D. Alexander; entrance of Pearl Locks, Oahu, and throughout Ewa district. Reference as for 1871.
	1875, July 29, 30, August 10.	9 40.4		H. M. S. Challenger; on spit south of town in $\phi=21° 18'.0$, $\lambda=157° 51'$ W. Voyage of H. M. S. Challenger, Narrative, vol. ii, London, 1882.
	1875..	9 15		Observer and reference as for first value of 1875. Shore of Waikiki, south of Honolulu. [Mean value = — 9°.40—Sch.]
17	1879..	9 32		Observer, position, and reference as for 1873.
18	1881..	9 40	E.	Observer, position, and reference as for 1873.

GROUP III.—*Series of Magnetic Stations mainly on the Pacific Coast, etc.*—**Continued.**

HONOLULU, ISLAND OF OAHU (WOAHOO), SANDWICH ISLANDS—Continued.

		° ′		
19	1883, June 17.	10 42	E.	Lieut. W. H. Parker in the U. S. S. Essex; at sea, in $\phi=21^\circ 15'$, $\lambda=156^\circ 13'$ W. Naval Professional Papers, No. 19, Washington, 1886. [Reduction to Honolulu inappreciable.—SCH.]
	1883, August 19.	9 09		Lieut. F. Hanford in the U. S. S. Pensacola; at sea, in $\phi=21^\circ 10'$, $\lambda=157^\circ 54'$ W. Naval Professional Papers, No. 19, Washington, 1886. [Reduction to Honolulu —3′, hence decl'n = —9° 12′; mean value for 1883.54, = —9°.95—SCH.]
20	1884.0.	10 14		Observer and reference as for 1873, at west base, Honolulu.
	1884.0.	9 30		C. J. Lyons, asst. H. G. S.; at old station of 1841 occupied by Commander C. Wilkes. Letters of Jan. 9 and Apr. 23, 1884.
	1884, January 4.	9 57	E.	Lieut. W. Swift in U. S. S. Alert; at sea, in $\phi=20^\circ 35'$, $\lambda=157^\circ 45'$ W. Naval Professional Papers, No. 19, Washington, 1886. [Reduction to Honolulu — 10′, hence declination = — 10° 07′. Mean of 3 determinations = — 9° 57′.—SCH]

The values available for discussion of the declination at the Sandwich Islands after rejecting 3 apparently anomalous ones for Kailua and 4 such in the Honolulu series are as follows:

KAILUA BAY, HAWAII.

No.	Year.	Decl'n.	No.	Year.	Decl'n.	No.	Year.	Decl'n.	No.	Year.	Decl'n.
		°			°			°			°
1	1779.5	—8.10		(1796.0)	(—9.20)	7	1825.5	—8.85	10	1853.5	—8.25
2	1791.7	8.03	5	1818.8	7.50		(1836.5)	(7.62)	11	1875.6	7.57
3	1793.2	7.78	6	1819.5	9.83	8	1841.5	8.83	12	1877.5	8.00
4	1796.0	8.25		(1824.5)	(10.23)	9	1845.2	9.35	13	1884.0	8.50

HONOLULU, OAHU.

No.	Year.	Decl'n.	No.	Year.	Decl'n.	No.	Year.	Decl'n.	No.	Year.	Decl'n.
		°			°			°			°
1	1792.2	—7.83	5	1827.5	—10.43	10	1845.1	—10.08	15	1873.5	—9.63
	(1793.5)	(5.87)	6	1836.5	10.18	11	1852.5	9.17	16	1875.5	9.40
2	1796.1	9.68	7	1837.5	10.32	12	1859.2	9.70	17	1879.5	9.54
	(1816.5)	(10.95)	8	1838.5	10.65		(1867.6)	(11.25)	18	1881.5	9.67
3	1819.5	10.40	9	1840.5	9.28	13	1871.5	9.60	19	1883.5	9.95
4	1825.0	9.87		(1841.5)	(8.25)	14	1872.5	9.30	20	1884.0	9.95

Observations inclosed within parentheses are proposed for omission in any process for representation that may be employed.

No expression of the above observations by means of a periodic function will for the present be attempted, as it seems impossible, without undue and arbitrary straining, to reconcile such a formula with the condition imposed upon by Mr. Lyons, *i. e.*, that the easterly declination was *increasing* on the islands from about the middle of the century to the present time; we therefore prefer to suspend our judgment as to the direction and amount of the secular change at the present time, and shall wait for further development.

In a volcanic region like that of the Sandwich Islands it is absolutely essential for the elucidation of the secular change in any of the magnetic elements that the successive observations should be made at the same stations, otherwise local disturbances may completely hide the true progressive movement and render all comparison nugatory. Even with this precaution we are obliged to assume that the law of secular change has not at times been suddenly interrupted through the agency of volcanic eruptions or through the effects of earthquakes.

A complete magnetic survey of this group of islands could not fail to throw much light on the distribution and character of the local disturbances as well as furnish evidence whether or not the secular change over disturbed and undisturbed regions is the same, and it is to be hoped that it will be undertaken by the Hawaiian Government Survey.

The Sandwich Islands group is magnetically considered no less interesting than are the Bermuda Islands, in which latter group, however, there is less liability to abrupt local changes in the curves representing the distribution of magnetism than in the former.

RESULTS FOR GROUP III.—Magnetic stations on the western coast and the Rocky Mountain region, inclusive of Mexico and Alaska and some foreign localities.

Geographical positions and expressions for the secular variation of the magnetic declination D (+West, —East). The letter m stands for t—1850.0 or for the difference in time, expressed in years and fraction of a year, for any time t and the middle of the century, within the range of observation at any station. A minus sign of D indicates east declination.

No.	Name of station and State.	Latitude.	West longitude.	The magnetic declination expressed as a function of time.
		° ′	° ′	° ° °
1	Acapulco, Mexico.	16 50.5	99 52.3	$D=-4.48+4.41\sin(1.0\,m-85.7)$*
2	Vera Cruz, Mexico.	19 11.9	96 08.8	$D=-5.09+4.22\sin(1.2\,m-63.4)$*
3	City of Mexico, Mexico.	19 26.0	99 11.6	$D=-5.34+3.28\sin(1.0\,m-87.9)$*
4	San Blas, Mexico.	21 32.5	105 18.4	$D=-6.22+3.20\sin(1.25\,m-103.2)$
5	El Paso, Tex.	31 46	106 30	$D=-9.10+3.40\sin(1.3\,m-108.4)$*
6	Magdalena Bay, Lower California.	24 38.4	112 08.9	$D=-8.87+2.20\sin(1.25\,m-163.7)$*
7	San Diego, Cal.	32 42.1	117 14.3	$D=-11.78+1.90\sin(1.15\,m-151.6)$
8	Santa Barbara, Cal.	34 24.2	119 43.0	$D=-12.97+2.08\sin(1.3\,m-146.3)$
9	Monterey, Cal.	36 36.1	121 53.6	$D=-13.79+2.65\sin(1.10\,m-156.4)$
10	San Francisco, Cal.	37 47.5	122 27.3	$D=-13.94+2.65\sin(1.05\,m-135.5)$
11	Salt Lake City, Utah.	40 46.1	111 53.8	$D=-12.40+4.25\sin(1.4\,m-121.6)$*
12	Cape Mendocino, Cal.	40 26.3	124 24.3	$D=-15.25+2.45\sin(1.10\,m-128.0)$*
13	Vancouver, Wash. T.	45 37.5	122 39.7	$D=-17.93+3.12\sin(1.35\,m-134.1)$*
14	Wallula, Wash. T.	46 05	118 55	$D=-17.00+3.08\sin(1.3\,m-118.1)$*
15	Cape Disappointment, Wash	46 16.7	124 02.8	$D=-19.39+2.54\sin(1.25\,m-158.7)$
16	Seattle, Wash. T.	47 35.9	122 20.0	$D=-19.15+3.14\sin(1.4\,m-136.5)$*
17	Port Townsend, Wash. T.	48 07.0	122 44.9	$D=-18.84+3.00\sin(1.45\,m-122.1)$
18	Nee-ah Bay, Wash. T.	48 21.8	124 38.0	$D=-19.83+2.91\sin(1.40\,m-141.6)$
19	Nootka, Vancouver Island.	49 35.5	126 37.5	$D=-21.25+2.74\sin(1.30\,m-152.0)$*
20	Sitka, Alaska.	57 02.9	135 19.7	$D=-25.79+3.30\sin(1.30\,m-104.2)$
21	Port Mulgrave, Alaska.	59 33.7	139 45.9	$D=-24.03+7.77\sin(1.30\,m-85.8)$
22	Port Etches, Alaska.	60 20.7	146 37.6	$D=-23.71+7.89\sin(1.35\,m-80.9)$
23	St. Paul, Kadiak Island.	57 48.0	152 21.3	$D=-22.21+5.18\sin(1.35\,m-72.5)$
24	Captain's and Iliuliuk Harbors	53 52.6	166 31.5	$D=-18.01+1.82\sin(1.3\,m-69.6)$*
25	Port Clarence, Alaska.	65 16	166 50	$D=-18.98+7.99\sin(1.3\,m-68.4)$*
26	Chamisso Island, Alaska.	66 13	161 49	$D=-23.62+7.64\sin(1.3\,m-64.0)$*
27	Petropavlovsk, Siberia.	53 01	201 17	$D=-3.35+2.97\sin(1.3\,m+12.2)$

* Approximate expression.

GROUP III.—*Comparison of observed and computed Magnetic Declinations.*

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
ACAPULCO, MEX.			
	°	°	°
1744.5	— 3.00	— 3.62	+ .62
1791.3	7.73	7.05	— .68
1822.5	8.67	8.53	— .14
1828.5	9.12	8.69	— .43
1838.0	8.29	8.85	+ .56
1866.5	8.37	8.60	+ .23
1874.2	8.64	8.36	— .28
1880.9	7.94	8.08	+ .14
1882.9	— 7.90	— 7.99	+ .09
VERA CRUZ, MEX.			
1727.0	— 2.25	— 2.92	+ .67
1769.4	6.57	6.53	— .04
1776.5	7.50	7.10	— .40
1815.5	10.62	9.17	—1.45
1819.3	9.27	9.24	— .03
1839.5	8.37	9.18	+ .81
1856.6	8.28	8.57	+ .29
1861.0	8.33	8.33	.00
1880.1	— 7.44	— 7.02	— .42
CITY OF MEXICO, MEX.			
1769.7	— 5.46	— 6.01	+ .55
1775.5	6.70	6.33	— .37
1804.0	8.13	7.70	— .43
1849.5	8.50	8.62	+ .12
1850.5	8.59	8.62	+ .03
1856.9	8.77	8.58	— .19
1858.5	8.37	8.56	+ .19
1860.5	8.50	8.54	+ .04
1862.5	8.46	8.52	+ .06
1867.0	8.15	8.44	+ .29
1868.5	8.17	8.41	+ .24
1879.8	8.58	8.12	— .46
1884.3	— 8.32	— 7.98	— .34
SAN BLAS, MEX.			
1788.2	— 5.00	— 6.20	+1.20
1791.3	7.47	6.41	—1.06
1822.0	— 8.67	— 8.35	— .32
SAN BLAS, MEX.—continued.			
	°	°	°
1837.5	— 8.85	— 9.02	+ .17
1838.5	8.79	9.06	+ .27
1839.5	9.00	9.09	+ .09
1841.5	9.20	9.15	— .05
1874.1	9.14	9.28	+ .14
1880.9	— 9.30	— 9.11	— .19
EL PASO, TEX.			
1852.5	—12.40	—12.38	— .02
1859.1	12.42	12.48	+ .06
1878.5	12.42	12.32	— .10
1884.3	—12.08	—12.15	+ .07
MAGDALENA BAY, LOWER CAL.			
1783.3	— 6.78	— 6.84	+ .06
1837.5	8.27	8.90	+ .63
1839.5	9.25	8.99	— .26
1866.4	10.67	10.19	— .48
1871.3	11.00	10.37	— .63
1873.3	10.56	10.44	— .12
1881.1	—10.48	—10.68	+ .20
SAN DIEGO, CAL.			
1783.3	—10.44	—10.36	— .08
1792.5	11.00	10.62	— .38
1839.5	12.34	12.21	— .13
1851.3	12.48	12.73	+ .25
1853.8	12.53	12.81	+ .28
1866.4	13.16	13.18	+ .02
1872.9	13.32	13.33	+ .01
1881.3	—13.46	—13.49	+ .03
SANTA BARBARA, CAL			
1783.3	—11.36	—11.31	— .05
1839.5	13.47	13.68	+ .21
1869.9	15.20	14.76	— .44
1881.3	—14.87	—14.97	+ .10
MONTEREY, CAL.			
	°	°	°
1783.3	—12.44	—11.77	— .67
1786.7	11.80	11.89	+ .09
1791.7	10.93	12.07	+1.14
1792.9	12.37	12.12	— .25
1794.9	12.37	12.19	— .18
1837.5	14.50	14.24	— .26
1839.5	14.22	14.34	+ .12
1841.5	15.00	14.44	— .56
1843.5	14.00	14.54	+ .54
1851.1	14.97	14.90	— .07
1854.4	14.98	15.05	+ .07
1873.7	15.92	15.81	— .11
1881.3	—15.90	—16.04	+ .14
SAN FRANCISCO, CAL.			
1783.3	—12.91	—12.80	— .11
1792.9	12.80	13.23	+ .43
1818.7	15.00	14.47	— .53
1827.5	15.45	14.89	— .56
1829.9	14.92	14.99	+ .07
1830.5	14.85	15.02	+ .17
1837.5	15.17	15.31	+ .14
1839.5	15.33	15.40	+ .07
1841.9	15.50	15.50	.00
1850.0	15.68	15.80	+ .12
1852.3	15.48	15.87	+ .39
1858.4	15.88	16.06	+ .18
1866.5	16.42	16.27	— .15
1871.9	16.38	16.39	+ .01
1872.8	16.43	16.40	— .03
1873.7	16.41	16.42	+ .01
1874.0	16.45	16.43	— .02
1879.2	16.57	16.50	— .07
1880.8	16.56	16.52	— .04
1881.5	16.48	16.53	+ .05
1883.4	16.64	16.54	— .10
1884.7	16.54	16.56	+ .02
1885.6	16.56	16.56	.00
1886.3	—16.55	—16.57	+ .02
SALT LAKE CITY, UTAH.			
1850.5	—15.57	—16.05	+ .48
1866.6	—16.50	—16.60	+ .10

GROUP III.—*Comparison of observed and computed Magnetic Declinations*—Continued.

SALT LAKE CITY, UTAH—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
	°	°	°
1869.4	—16.61	—16.64	+ .03
1872.5	17.02	16.65	— .37
1878.7	16.77	16.60	— .17
1881.4	16.47	16.55	+ .08
1883.9	16.24	16.49	+ .25
1884.8	16.23	16.46	+ .23
1885.9	—16.49	—16.42	— .07

CAPE MENDOCINO, CAL.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1783.3	—14.17	—14.36	+ .19
1786.7	14.90	14.51	— .39
1792.3	15.78	14.77	—1.01
1794.7	13.88	14.88	+1.00
1854.3	16.93	17.30	+ .37
1886.3	—18.01	—17.70	— .31

VANCOUVER, WASH. T.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1788.6	—14.57	—16.05	+1.48
1839.5	19.37	19.57	+ .20
1859.5	21.50	20.60	— .90
1860.5	20.08	20.64	+ .56
1881.8	—20.89	—21.05	+ .16

WALLULA, WASH. T.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1853.0	—19.67	—19.81	+ .14
1860.5	20.00	19.98	— .02
1861.5	20.50	20.00	— .50
1881.7	—19.93	—20.00	+ .07

CAPE DISAPPOINTMENT, WASH. T.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1783.3	—16.39	—17.15	+ .76
1786.7	18.00	17.24	— .76
1792.3	18.00	17.42	— .58
1839.5	19.18	19.75	+ .57
1842.5	20.00	19.91	— .09
1851.5	20.32	20.39	+ .07
1858.5	21.00	20.73	— .27
1873.8	21.44	21.37	— .07
1881.8	—21.60	—21.61	+ .01

SEATTLE, DUWAMISH BAY, WASH. T.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
	°	°	°
1783.3	—16.75	—16.75	.00
1855.5	21.42	21.60	+ .18
1871.8	22.59	22.17	— .42
1881.8	—22.04	—22.29	+ .25

PORT TOWNSEND, WASH. T.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1783.3	—17.00	—16.96	— .04
1841.5	20.67	20.98	+ .31
1856.6	21.66	21.63	— .03
1857.5	21.77	21.64	— .13
1862.5	22.00	21.75	— .25
1876.1	21.98	21.82	— .16
1881.9	—21.45	—21.75	+ .30

NEE-AH BAY, CAPE FLATTERY, WASH. T.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1783.3	—17.25	—17.45	+ .20
1792.3	18.00	17.87	— .13
1841.5	22.50	21.13	—1.37
1852.6	21.50	21.78	+ .28
1855.6	21.80	21.93	+ .13
1881.8	—22.74	—22.72	— .02

NOOTKA S'D, VANCOUVER IS'D.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1778.2	—19.75	—18.76	— .99
1783.3	17.91	18.91	+1.00
1786.6	19.78	19.02	— .76
1792.8	18.37	19.27	+ .90
1860.5	23.78	23.07	— .71
1863.5	23.08	23.21	+ .13
1881.7	—23.60	—23.81	+ .21

SITKA, ALASKA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1779.5	—23.50	—24.89	+1.39
1786.5	26.77	25.40	—1.37
1787.4	24.00	25.47	+1.47
1791.6	27.77	25.79	—1.98
1804.6	26.75	26.74	— .01
1818.5	27.25	27.67	+ .42
1824.5	—27.50	—28.02	+ .52

SITKA, ALASKA—continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
	°	°	°
1827.5	—28.83	—28.19	— .64
1829.9	28.31	28.31	.00
1838.6	28.62	28.68	+ .06
1842.6	28.54	28.81	+ .27
1843.5	28.90	28.84	— .06
1844.5	28.96	28.86	— .10
1845.5	29.00	28.89	— .11
1847.7	28.98	28.94	— .04
1848.5	29.08	28.96	— .12
1849.1	29.06	28.97	— .09
1850.5	28.84	29.00	+ .16
1851.5	28.88	29.01	+ .13
1852.4	28.81	29.03	+ .22
1856.5	28.98	29.07	+ .09
1857.5	29.12	29.08	— .04
1858.5	29.18	29.08	— .10
1859.5	29.10	29.09	— .01
1860.5	29.13	29.09	— .04
1861.5	29.07	29.09	+ .02
1862.5	29.02	29.09	+ .07
1863.5	29.06	29.08	+ .02
1864.5	29.07	29.08	+ .01
1867.6	28.82	29.05	+ .23
1874.3	28.99	28.93	— .06
1876.1	28.34	28.90	+ .56
1879.3	28.90	28.81	— .09
1880.4	29.08	28.77	— .31
1881.7	—29.19	—28.73	— .46

PORT MULGRAVE, YAKUTAT BAY, ALASKA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1778.3	—23.80	—24.14	+ .34
1787.4	26.00	25.75	— .25
1791.5	26.67	26.46	— .21
1794.5	26.00	26.94	+ .94
1802.0	29.00	28.13	— .87
1823.5	30.50	30.74	+ .24
1874.4	29.97	30.32	+ .35
1880.5	—30.00	—29.64	— .36

PORT ETCHES, ALASKA.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
1778.4	—23.62	—24.04	+ .42
1787.4	—26.25	—25.69	— .56

Group III.—*Comparison of observed and computed Magnetic Declinations*—Continued.

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
PORT ETCHES, ALASKA—continued.			
	°	°	°
1788.4	—25.00	—25.87	+ .87
1790.5	26.23	26.25	+ .02
1794.5	28.50	26.94	— 1.56
1810.5	28.13	29.36	+1.23
1830.5	31.63	31.24	— .39
1837.7	31.63	31.53	— .10
1874.4	—29.16	—29.57	+ .41
ST. PAUL, KADIAK IS'D, ALASKA.			
1778.4	—22.10	—23.18	+1.08
1790.5	25.50	24.58	— .92
1804.6	26.12	25.95	— .17
1808.5	25.75	26.27	+ .52
1818.5	26.50	26.90	+ .40
1834.5	28.63	27.38	—1.25
1839.5	26.72	27.38	+ .66
1845.5	27.00	27.29	+ .29
1867.7	—26.08	—26.09	+ .01

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
ST. PAUL, KADIAK IS'D, ALASKA—cont'd.			
	°	°	°
1874.4	—25.37	—25.51	+ .14
1880.5	—25.15	—24.90	— .25
CAPTAIN'S AND ILIULIUK HARBORS, UNALASHKA.			
1790.4	—19.58	—19.00	— .58
1792.5	19.00	19.07	+ .07
1817.5	19.40	19.70	+ .30
1827.6	19.83	19.81	— .02
1831.5	19.50	19.83	+ .33
1849.5	20.00	19.72	— .28
1867.7	19.79	19.33	— .46
1870.5	19.75	19.25	— .50
1873.5	19.06	19.15	+ .09
1874.7	18.71	19.12	+ .41
1880.6	18.63	18.91	+ .28
1883.7	—18.71	—18.80	+ .09
PORT CLARENCE, ALASKA.			
1827.5	—26.91	—26.90	— .01
1850.5	—26.43	—26.38	— .05

Year and fraction.	Obs'd decl'n.	Comp'd decl'n.	O—C.
PORT CLARENCE—continued.			
	°	°	°
1854.5	—26.00	—26.08	+ .08
1879.5	23.02	22.98	— .04
1880.7	—22.75	—22.79	+ .04
CHAMISSO IS'D, ALASKA.			
1826.5	—31.29	—31.24	— .05
1849.5	30.43	30.52	+ .09
1880.7	—26.82	—26.74	— .08
PETROPAVLOVSK, KAMTCHATKA.			
1779.5	— 6.31	— 6.27	— .04
1792.5	6.00	5.98	— .02
1804.7	5.49	5.51	+ .02
1827.6	4.07	4.21	+ .14
1837.7	3.45	3.54	+ .09
1849.5	2.62	2.75	+ .13
1854.5	3.67	2.43	—1.24
1866.5	1.42	1.70	+ .28
1876.6	— 1.15	— 1.18	+ .03

RESULTS FOR GROUP III—Continued.

Contents of columns: Year of first observation, and whole number of observations used in the discussion, probable error of an observation; resulting epoch of nearest *extreme easterly* declination, with amount of maximum deflection at that epoch. A minus sign indicates east declination; annual change about the present time, for four epochs, at intervals of five years; a plus sign indicates diminishing easterly declination, a minus sign the reverse change.

Number.	Station.	Year of first observation.	Number of observations.	Probable error of an observation.	Epoch of eastern elongation.	Maximum declination at epoch.	Annual change in— 1880.0	1885.0	1890.0	1895.0
				′		°	′	′	′	′
1	Acapulco.	1744	9	±20	1846	− 8.9	+2.6	+ 2.9	+ 3.2	+ 3.5
2	Vera Cruz.	1727	9	28	1828	− 9.3	+4.7	+ 4.9	+ 5.1	+ 5.2
3	City of Mexico.	1769	13	13	1848	− 8.6	+1.8	+ 2.1	+ 2.3	+ 2.5
4	San Blas.	1788	9	28	1861	− 9.4	+1.7	+ 2.1	+ 2.5	+ 2.9
5	El Paso.	1852	4	10	1864	−12.5	+1.6	+ 2.1	+ 2.6	+ 3.0
6	Magdalena Bay.	1783	7	22	1909	−11.1	−1.7	− 1.4	− 1.2	− 0.9
7	San Diego.	1783	8	10	1904	−13.7	−1.0	− 0.8	− 0.6	− 0.4
8	Santa Barbara.	1783	4	15	1893	−15.0	−0.8	− 0.5	− 0.2	− 0.1
9	Monterey.	1783	13	20	1910	−16.4	−1.7	− 1.4	− 1.1	− 0.9
10	San Francisco.	1783	24	10	1893	−16.6	−0.7	− 0.4	− 0.2	+ 0.1
11	Salt Lake City.	1850	9	12	1873	−16.7	+1.1	+ 1.8	+ 2.5	+ 3.2
12	Cape Mendocino.	1783	6	37	1886	−17.7	−0.2	0.0	+ 0.3	+ 0.6
13	Vancouver.	1788	5	36	1883	−21.0	−0.3	+ 0.2	+ 0.8	+ 1.3
14	Wallula.	1853	4	21	1872	−20.1	+0.8	+ 1.2	+ 1.7	+ 2.1
15	Cape Disappointment.	1783	9	23	1905	−21.9	−1.7	− 1.4	− 1.1	− 0.7
16	Seattle.	1855	3	21	1883	−22.3	−0.4	+ 0.2	+ 0.8	+ 1.3
17	Port Townsend.	1841	6	11	1872	−21.8	+0.9	+ 1.5	+ 2.0	+ 2.5
18	Nee-ah Bay.	1783	6	19	1887	−22.7	−0.7	− 0.2	+ 0.3	+ 0.8
19	Nootka.	1778	7	40	1898	−24.0	−1.5	− 1.0	− 0.6	− 0.2
20	Sitka.	1779	35	21	1861	−29.1	+1.9	+ 2.3	+ 2.7	+ 3.1
21	Port Mulgrave.	1778	8	28	1847	−31.8	+7.2	+ 8.1	+ 8.8	+ 9.4
22	Port Etches.	1778	9	36	1843	−31.6	+8.5	+ 9.3	+ 9.9	+10.5
23	St. Paul, Kadiak.	1778	11	31	1837	−27.4	+6.2	+ 6.6	+ 6.9	+ 7.2
24	Captain's and Iliuliuk Harbors.	1790	12	14	1834	−19.8	+2.1	+ 2.3	+ 2.4	+ 2.4
25	Port Clarence.	1827	5	15	1833	−27.0	+9.5	+10.0	+10.4	+10.7
26	Chamisso Island.	1826	3	15	1830	−31.3	+9.4	+ 9.9	+10.2	+10.4
27	Petropavlovsk.	1779	9	16	1771	− 6.3	+2.5	+ 2.2	+ 1.8	+ 1.3

RESULTS FOR GROUP III—Completed.

Ephemeris of magnetic declinations. Computed magnetic declination at each station for every tenth year of the series, and after 1850 for every fifth year. A minus sign signifies east declination, a plus sign west declination. The *first* tabular result for any station indicates that the first observation made there falls between the tabular date and the next one following it.

Year (January 1).	Acapulco, Mexico.	Vera Cruz, Mexico.	City of Mexico, Mexico.	San Blas, Mexico.	El Paso, Tex.	Magdalena Bay, Lower California.	San Diego, Cal.	Santa Barbara, Cal.	Monterey, Cal.
	°	°	°	°	°	°	°	°	°
1700	----	----	----	----	----	----	----	----	----
10									
20		—2.4							
30		3.2							
40	—3.3	4.0							
50	4.0	4.8	----	----	----	----	----	----	----
60	4.8	5.7	—5.4						
70	5.6	6.6	6.0						
80	6.3	7.4	6.6	—5.6		—6.8	—10.3	—11.2	—11.7
90	7.0	8.0	7.1	6.3		7.0	10.5	11.5	12.0
1800	7.6	8.6	7.5	7.0	----	7.3	10.9	11.9	12.41
10	8.1	9.0	7.9	7.7		7.7	11.21	12.3	12.87
20	8.5	9.3	8.2	8.24		8.1	11.58	12.8	13.36
30	8.7	9.3	8.5	8.73		8.5	11.96	13.25	13.86
40	8.9	9.2	8.6	9.10		9.0	12.33	13.70	14.37
50	8.88	8.86	8.62	9.33	—12.3	9.48	12.68	14.12	14.85
55	8.83	8.64	8.59	9.39	12.4	9.71	12.85	14.31	15.08
60	8.75	8.39	8.55	9.42	12.49	9.93	13.00	14.48	15.29
65	8.64	8.10	8.48	9.40	12.50	10.13	13.14	14.64	15.49
70	8.50	7.77	8.39	9.35	12.47	10.32	13.27	14.77	15.69
75	8.33	7.41	8.26	9.26	12.40	10.49	13.38	14.87	15.85
80	8.12	7.03	8.13	9.14	12.28	10.64	13.47	14.96	16.00
85	7.89	6.63	7.96	8.98	12.13	10.78	13.55	15.0	16.13
90	7.64	6.21	7.77	8.78	11.9	10.88	13.6	15.0	16.24
1895	—7.4	—5.8	—7.6	—8.6	—11.7	—11.0	—13.6	—15.0	—16.3

RESULTS FOR GROUP III—Completed.

Year (January 1).	San Francisco, Cal.	Salt Lake City, Utah.	Cape Mendocino, Cal.	Vancouver, Wash. T.	Wallula, Wash. T.	Cape Disappointment, Wash. T.	Seattle, Duwamish Bay, Wash. T.	Port Townsend, Wash. T.	Nee-ah Bay, near Cape Flattery, W. T.
	°	°	°	°	°	°	°	°	°
1700	----	----	----	----	----	----	----	----	----
10									
20									
30									
40									
50	----	----	----	----	----	----	----	----	----
60									
70									
80	—12.6		—14.2	—15.6		—17.1		—16.8	—17.3
90	13.1		14.7	16.1		17.3		17.4	17.8
1800	13.6	----	15.1	16.8	----	17.7	----	18.1	18.3
10	14.1		15.6	17.5		18.2		18.8	18.9
20	14.54		16.0	18.2		18.7		19.6	19.6
30	15.00		16.5	18.9		19.2		20.3	20.3
40	15.42		16.9	19.6		19.8		20.9	21.0
50	15.79	—16.0	17.2	20.17	—19.7	20.31	—21.3	21.38	21.64
55	15.96	16.3	17.3	20.41	19.9	20.56	21.6	21.57	21.90
60	16.10	16.45	17.4	20.62	20.0	20.80	21.8	21.70	22.13
65	16.23	16.58	17.5	20.78	20.1	21.02	22.0	21.79	22.33
70	16.34	16.64	17.6	20.91	20.1	21.22	22.13	21.83	22.50
75	16.44	16.64	17.6	21.00	20.1	21.40	22.23	21.83	22.62
80	16.51	16.58	17.69	21.04	20.0	21.56	22.28	21.78	22.70
85	16.56	16.45	17.70	21.05	19.9	21.69	22.29	21.68	22.74
90	16.58	16.3	17.69	21.0	19.8	21.79	22.25	21.54	22.73
1895	—16.6	—16.0	—17.7	—20.9	—19.6	—21.9	—22.2	—21.3	—22.7

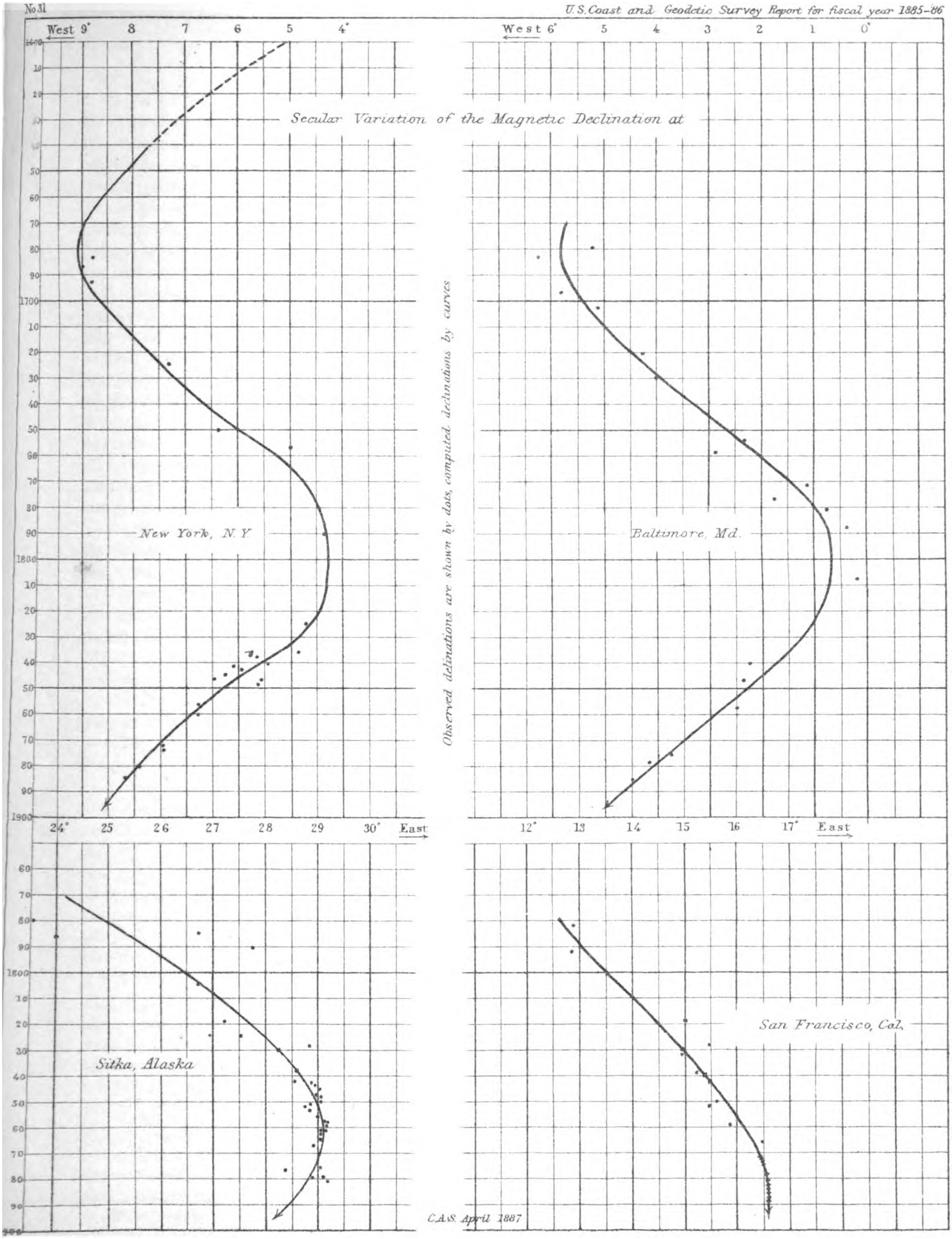
RESULTS FOR GROUP III—Completed.

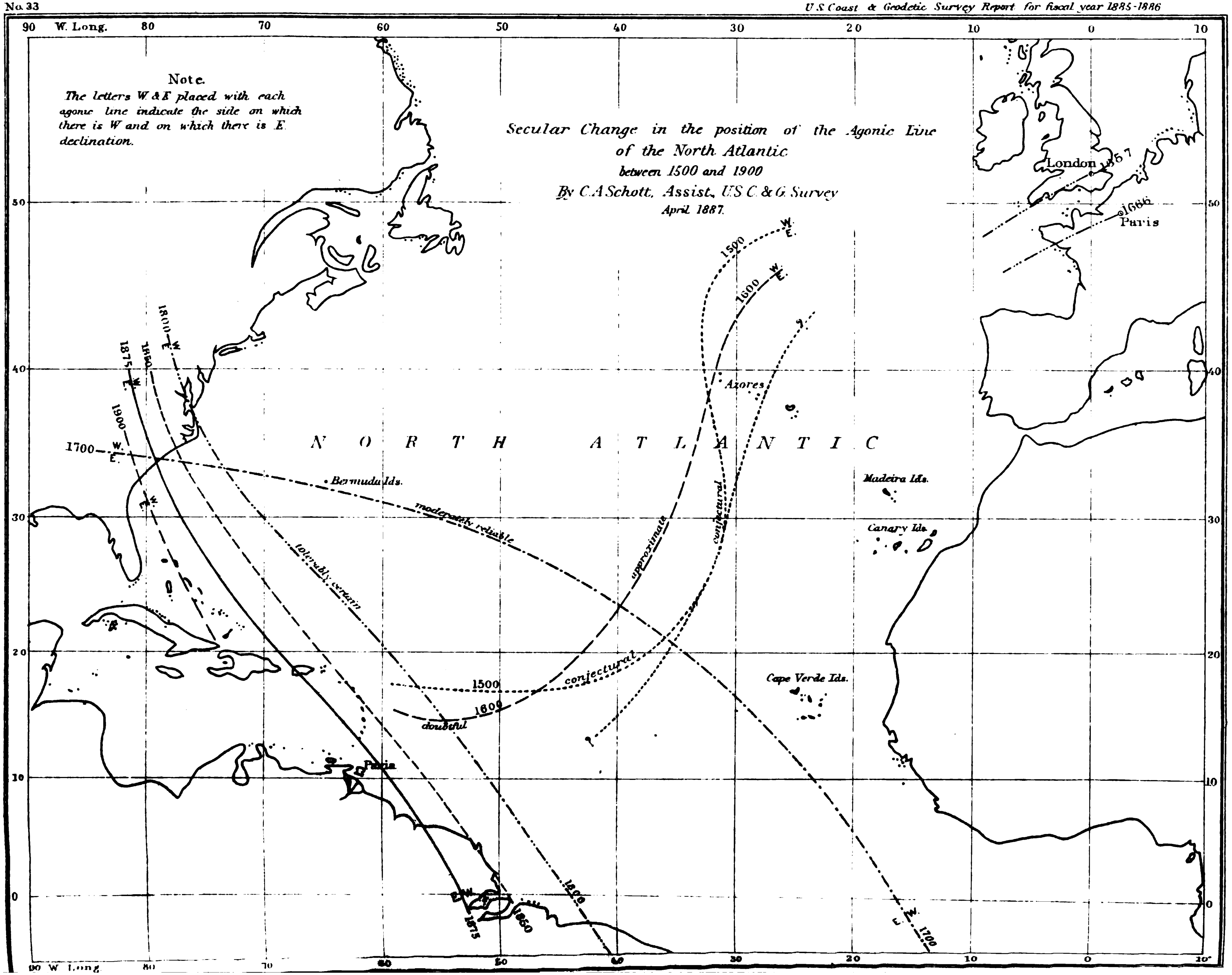
Year (January 1).	Nootka, Vancouver Island.	Sitka, Alaska.	Port Mulgrave, Yakutat Bay, Alaska.	Port Etches, Alaska.	St. Paul, Kadiak Island.	Captain's and Illiuliuk Harbors, Unalashka Island.	Port Clarence, Alaska.	Chamisso Island, Kotzebue Sound.	Petropavlovsk, Kamtchatka, Siberia.
	°	°	°	°	°	°	°	°	°
1700	----	----	----	----	----	----	----	----	----
10									
20									
30									
40									
50	----	----	----	----	----	----	----	----	----
60									
70	—18.6	—24.2	—22.7	—22.5	—22.2				—6.3
80	18.8	24.9	24.5	24.4	23.4	—18.6			6.26
90	19.2	25.7	26.2	26.16	24.5	19.0			6.06
1800	19.6	26.41	27.82	27.84	25.54	19.32	----	----	5.72
10	20.1	27.12	29.25	29.28	26.37	19.56			5.25
20	20.7	27.76	30.41	30.44	26.98	19.73	—26.6	—31.1	4.69
30	21.3	28.31	31.24	31.22	27.32	19.82	27.0	31.3	4.06
40	22.0	28.72	31.71	31.58	27.38	19.75	26.9	31.1	3.39
50	22.54	28.99	31.78	31.50	27.15	19.71	26.4	30.5	2.72
55	22.80	29.06	31.66	31.30	26.93	19.63	26.0	30.1	2.40
60	23.05	29.09	31.45	30.99	26.65	19.53	25.6	29.6	2.08
65	23.27	29.08	31.14	30.59	26.31	19.41	25.0	29.0	1.79
70	23.47	29.02	30.74	30.09	25.90	19.27	24.4	28.3	1.51
75	23.63	28.92	30.26	29.49	25.45	19.11	23.7	27.6	1.26
80	23.77	28.79	29.69	28.8	24.96	18.94	22.9	26.8	1.03
85	23.88	28.6	29.06	28.1	24.4	18.75	22.1	26.0	0.84
90	23.95	28.4	28.4	27.3	23.9	18.56	21.2	25.2	0.7
1895	—24.0	—28.2	—27.6	—26.4	—23.3	—18.4	—20.4	—24.3	—0.6

GRAPHICAL ILLUSTRATION OF THE SECULAR VARIATION.

In a preceding part of this paper we have already made use of the graphical method to exhibit to the eye the motion of the needle as observed at Paris, and since this kind of representation has the great advantage of readily impressing the facts on the memory and of affording easy comparisons and generalizations, the secular motion as observed at four leading stations is introduced on plate No. 31. These stations are New York, Baltimore, San Francisco, and Sitka. As an aid to mnemonics on the diagrams, the degrees of easterly declination are shown to increase toward the right or east, and consequently the degrees of westerly declination increase towards the left or west, the ordinates being considered as directed north and south (true); the time scale increases downward where additional observations can be plotted more conveniently than on the top. The observed declinations are shown by dots, the computed declinations by a continuous curved line. These diagrams show in a conspicuous manner the great regularity and persistency of the secular variation, and thus impress the mind with the fact that the explanation of it must ultimately be referred to forces of a periodic character simultaneously acting over large areas and with great regularity, and probably having their source directly or indirectly in the sun, and with a probable dependence on planetary configurations. The effect of these deflecting forces on the magnetic condition at points on the earth's surface undergoes modifications as manifested in the observed variations of the amplitude and in the duration of the secular oscillation at places geographically widely distributed. So far, however, we are not in possession of any theory or even of a plausible working hypothesis as to the true cause or origin of the secular variation, and consequently are constrained to pursue the inquiry empirically by means of observation and discussion.

On map No. 32 we give the annual change of the declination for the epoch 1890, for all places discussed and falling within the limits of the map. The numbers are expressed in minutes of arc, and are directly taken from the preceding tables. A plus sign indicates increasing west or decreasing east declination, as the case may be. To know where the declination is west and where it is east, the agonic line (or line of no deviation) for 1890 is introduced; for all places to the right, or to the north and east, of this line the declination is west at that epoch, and for all places to the left, or to the south and west, of it, it is east at that time. The map also shows the positions of this agonic for the epoch 1795, at which time it had about reached its extreme northeastern position, having come up from the southward; apparently it rested here a few years and then commenced to retreat over its previous course. At that time, in this vicinity, it passed between Washington and Baltimore, and extended out to sea just south of Cape Henry, Va. It is not easy to determine the exact time of stationary condition; there may be an uncertainty of several years in consequence of the ordinary irregularities in the direction of the needle and the extreme smallness of the secular effect, which is overlaid and hidden by the former. There are likewise shown the positions of the agonic line for the epochs 1850 and 1875, and it is hardly necessary to remark that while about 1795 its geographical change was nil, its rate of change southward along our Atlantic coast has continually been increasing; it will reach a maximum at the time of the middle of the secular swing. It will be noticed that for nearly the whole of the United States (within the limit of the map) the annual change has a positive sign; in other words, the north end of the needle moves westward, increasing west or diminishing east declination, and the same is true for Alaska; but there are two regions of exception where the opposite of this motion is observed, viz, one in the extreme northeast, outside of our territory, in Newfoundland and part of Nova Scotia, the other in the extreme west, which is less accurately known than the other in consequence of its great extent over a comparatively little explored area between Mexico and British Columbia. Shaded bands on the map indicate the boundaries of the opposite regions within which the north end of the needle moves in opposite direction, hence these bands occupy places where, in 1890, the needle will have apparently ceased to move, or will have assumed, temporarily, a stationary condition; *western* elongation having been reached at all places within the Nova Scotia belt, and *eastern* elongation at all places within the western coast belt. These bands, like the agonic or any other isogonic curve, continually and gradually shift their position, to which circumstance we shall presently recur. It would not be difficult to construct curves of *equal annual change* for any given epoch, as was done by the writer for a limited area (Coast Survey Report for 1865, plate No. 28), in which system the above belts would form the zero lines, but the subject is sufficiently plain without


Secular Variation of the Magnetic Declination at
New York, N.Y.
Baltimore, Md.
Sitka, Alaska
San Francisco, Cal.
Observed declinations are shown by dots, computed declinations by curves
West
East
C.A.S. April 1887


Note.
The letters W & E placed with each agonic line indicate the side on which there is W and on which there is E declination.
Secular Change in the position of the Agonic Line of the North Atlantic between 1500 and 1900
By C. A. Schott, Assist., U.S. C. & G. Survey
April 1887.
NORTH ATLANTIC
London
1657
1666
Paris
Azores
Bermuda Ids.
Madeira Ids.
Canary Ids.
Cape Verde Ids.
Pará
moderately reliable
tolerably certain
approximate
conjectural
doubtful
1500
1600
1700
1800
1850
1875
1900
W. Long.

such aid. The line of maximum annual change might be expected to lie geographically midway between the two zero regions, which we find roughly to be the case.

On plate No. 33 an attempt is made to exhibit the changes which the (so called) agonic line of the North Atlantic has apparently undergone since its first discovery by Columbus in 1492.* It shows the several positions of that line for the epochs 1500, 1600, 1700, 1800; also for 1850, 1875, and for 1900 prospectively. The earliest position is quite conjectural, and rests on the observation of Columbus for its place in the mid-Atlantic, and for a second point on it, farther north, on an observation by Sebastian Cabot.† We also have reason to suppose the line to have passed over a region in the vicinity of Paris, and over a region including the Antilles. The second position, that for 1600, is taken from Hansteen's work (of 1819) and may be considered as a rough approximation; some change was made by me at its western end. The position for 1700 is more reliable, since it depends directly on numerous observations collected by Halley; it is taken from his chart. The positions for 1800 and 1850 require no further explanation; that of 1900, though prospective, is quite certain, considering the small scale of the map.

Upon the whole the general direction of the isogonic system in the vicinity of the agonic line of the North Atlantic appears to have been swaying forward and backward in a rather irregular way, with a preponderance, after 1600, toward a direction like that in which astronomical azimuths are counted.

Progressive change in the secular variation.—The progressive change noticed when examining at different times the position of the lines where the needle has arrived at elongation or at extreme range in the secular motion has already been referred to in a general way, and the systematic propagation of the phase of *eastern* elongation across the United States, from the Atlantic to the Pacific, in about the lapse of a century, has been adverted to. Under the present heading it is proposed to enter somewhat more minutely into this remarkable phenomenon.

The following figures are taken directly from our table, column headed "Nearest epoch of *east* elongation," and beginning in the extreme northeast we find the years of occurrence of this stationary phase of east elongation at different localities as follows:

Halifax, N. S.	1713	Marietta and Cincinnati, Ohio	1815
Eastport, Me.	1749	Florence, Ala.	1821
Portland, Me.	1778	St. Louis, Mo.	1820 (?)
Boston and Cambridge, Mass.	1780	Chicago, Ill.	1832
New Haven and Hartford, Conn.	1800	Salt Lake, Utah.	1873
New York, N. Y.	1799	Vancouver, Wash. T.	1883
Philadelphia, Pa.	1802	Cape Mendocino, Cal.	1886
Pittsburgh, Pa.	1808	San Francisco, Cal.	1893 (Computed.)

* For particulars see two papers in Coast and Geodetic Survey Report for 1880, viz: Appendix No. 18: "An attempt to solve the problem of the first landing place of Columbus in the New World," by Capt. G. V. Fox, Assistant Secretary of the Navy, 1861–'66; and Appendix No. 19: "An inquiry into the variation of the compass off the Bahama Islands at the time of the landfall of Columbus, in 1492," by Charles A. Schott, Assistant Coast Survey. In connection with this subject it may be remarked *en passant* that, in the writer's opinion, the controversy about the first landing place, and the track of Columbus among the West India Islands, may now be considered as closed (save the identification of the first harbor in Cuba) by the recent labors of Lieut. J. B. Murdock, U. S. N.: "The Cruise of Columbus in the Bahamas, 1492." The landfall took place, undoubtedly, at Watling's Island, as insisted upon by Captain Becher, in 1856, but in attempting to trace the *subsequent* track he failed, in consequence mainly of an erroneous assumption of the magnetic declination prevailing at the time of Columbus.

† Soon after the discovery by Columbus of a point of no variation in the Atlantic, Sebastian Cabot discovered a second one farther north, and evidently belonging to the same agonic curve. Livio Sanuto states, in his Geographica Distincta (Venice, 1588), that he procured the information from Sebastian Cabot and made use of his map (probably that composed in 1544), on which the position of the meridian intersecting the point of no variation was seen to be one hundred and ten miles to the *west* of the island of Flores, one of the Azores; see "Narrative and Critical History of America," by Justin Winsor, Vol. III, Boston and New York, 1884, p. 41. This discovery probably was made on the second voyage of the Cabots, or in 1498, although it may have been noted in the first, in 1497, by the elder Cabot. The latitude of the point is uncertain, but may be approximated from the fact that in the first voyage land was apparently sighted at Cape Breton, and in the second the coast of Newfoundland (Baccalaos), which is said to have been made from the north.

In the course of a conversation with Contarini, the Venetian ambassador to Charles V, in 1522, Sebastian Cabot told the ambassador that he had a method for ascertaining, *by the needle*, the distance between two places from east to west, which had never previously been discovered by any one. Ibid., p. 50.

In this idea, however, he was also anticipated by Columbus.

These places and corresponding times suffice to bring into strong relief the gradual progress within our geographical borders of what may aptly be called the crest (or hollow, as we may conceive) of the magnetic secular wave clear across the North American continent in about a century's time. This transfer of the eastern-elongation phase thus took place from east to west across the country; hence it is highly probable and may reasonably be inferred that with the present passing out into the Pacific of the eastern-elongation phase and the coming in of the opposite or western-elongation phase in the east, this invasion of the latter phase, already commenced in Northeastern Maine, will likewise propagate itself in the course of time over and across the continent; in fact our formulæ do suppose this to take place. The question whether our table of dates of the eastern-elongation phase can be extended so far east as to reach Europe cannot be definitely answered. We have for St. John's, Newfoundland, the date of 1741, and for Paris the year 1581, for the epoch of this phase, but unfortunately no intermediate stations at which to follow up the motion; observations at the Azores, in southern Greenland, and in Iceland may possibly come to light to assist in this inquiry.

If we follow up the dates of the eastern magnetic elongation going south along our Atlantic coast, thence across the Gulf of Mexico and north along the western coast, we notice the same law of gradual change as in our first table. A curve of equal date would fairly run parallel to our Atlantic coast line, and hold even as far south as Havana and Panama; similarly a curve of equal date on the western coast from Lower California up to the Straits of Fuca would not greatly deviate from it.

Charlottetown, Pr. Ed. Island	1734	City of Mexico	1848
Eastport, Me.	1749	San Blas, Mex.	1861
Nantucket, Mass.	1769	Santa Barbara, Cal.	1893 (Computed.)
Cape Henlopen, Del.	1801	Seattle, Wash. T.	1883
Charleston, S. C., and Savannah, Ga.	1794	Nee-ah Bay, Cape Flattery	1887
Havana, Cuba	1797	Nootka, Vancouver Island	1898 (Computed.)
Vera Cruz, Mex.	1828		

Beyond Vancouver Island and as we enter Alaska the dates again become earlier, as at Sitka, 1861, and in the whole region to the northward and westward, and including the chain of islands, the average date probably varies between 1830 and 1840 or thereabout. Near the eastern coast of Asia, west of Kamtchatka, we encounter a complex system of isogones whose secular development, however, lies outside the limits of our research.

With respect to secular variation, then, our magnetic weather is coming in from the northeast, and we already note the past occurrence of the western-elongation phase at Newfoundland in 1870, and at Prince Edward Island in 1884, with its expectation at Halifax in 1893, at Eastport in 1899, and at Portland in 1913. Should the Paris date 1812 be connected with this, the speed across the Atlantic must have been very different from that of the earlier east-elongation phase; all this, however, is at present matter of speculation.

Looking over the numerical values of a, on which the length of the period depends, we notice a relation to geographical position, as in the case of the epochal quantity c, of our general formula, just considered, but less marked.

For stations on our Atlantic coast the values a are generally included between 1.30 and 1.55, implying periods of 277 and 232 years respectively, and the same limits will apply to the generality of places in the interior.

For stations south of the United States the value of a is decidedly less, as at Kingston, Panama, Acapulco, City of Mexico, for which a varies between 1.0 and 1.1, with corresponding periods of 360 and 327 years. The value of a for western coast stations, as San Diego, Santa Barbara, Monterey, San Francisco, and Cape Mendocino, remains low, averaging 1.15 (period 313 years); in Alaska it rises again to about 1.30 (period 277 years), with but little variation.

At first sight this diversity in the length of the period would seem to present a great obstacle in the way of explaining the cause of the secular variation through the action of an external or cosmical disturbing force which would be supposed to act alike at all stations. If we suppose the changes in the direction of the magnetic needle to be due to changes in the direction of electric currents or of electric impulses or waves traversing the earth's crust and permeating the same to a considerable depth, and altering by inductive action the magnetic condition of the earth itself,

we may see in the diversity of the length of the period, and of the magnitude of deflection at different places, the effect of a systematic *swaying* in the position and intensity of such electric currents.

For the further development of the laws of secular variation in North America it would be of great importance to know what has been going on in the immediate vicinity of the magnetic pole (where the dip is 90° and the horizontal force zero) since Ross visited the region, now more than half a century ago. We have no direct or observational evidence whatever whether the pole remained stationary or has shifted its position, and if the latter, how much and in what direction.

In conclusion a few remarks may be made respecting the accuracy of the observations, shown in the tabular values of probable errors as derived from the differences of observed and computed values.

The probable errors of observation given in the tables will serve to convey some idea of the relative value of each series of observations. The imperfections in the instrumental means and methods of the older observations in many cases react unfavorably on the modern observations, which are made with more precise instruments and by more refined methods. If we take, for instance, the observations of Hudson, made in 1609, in the vicinity of New York, we find each fairly chargeable with a probable error of about ±3 or 4°. While these observations are very imperfect, those of Champlain of about the same period (1604 to 1612) are no better. These two navigators differ nearly 9° off the mouth of the Penobscot, Maine, and nearly 12° off Cape Cod. The observations made by Vancouver on our western coast, between 1792 and 1794, are each subject to a probable uncertainty of ± 1°, and even in our own days it requires very favorable circumstances to determine the variation of the compass at sea with a probable error of say half a degree or less. Increased precision was attained with the improvement of the azimuth compass and by allowance for disturbing effect of the ship's iron, and, with respect to shore stations, greater accuracy was obtained by the introduction of the theodolite for determining the astronomical meridian. With a portable magnetometer and a collimator magnet, the instrumental means need not introduce a greater uncertainty than about one minute; but the actual probable error of any determination is dependent also on the irregular variations in the direction of the magnetic force from day to day, thus making it desirable and indispensable for precise work to continue the observations for three or more days and to correct the individual results for diurnal variation. The amount of the probable error of an observed declination depends also on the intensity of the horizontal component of the magnetic force at the place, *i. e.*, in general the smaller the horizontal force the larger the apparent probable uncertainty.

APPENDIX No. 13—1886.

ON THE CIRCULATION OF THE SEA THROUGH NEW YORK HARBOR.

A Report by HENRY MITCHELL, Assistant.

WASHINGTON, D. C., *May* 6, 1887.

SIR: The following is offered as my report on the recent physical survey in New York Harbor, although it is almost exclusively confined to a single proposition and its demonstration. Mr. Marindin, who has already submitted to you his statistics of field work, will report on his studies of the *water contours* as soon as his levels are completed.

Very respectfully, yours,

HENRY MITCHELL,
Assistant United States Coast and Geodetic Survey.

Mr. F. M. THORN,
Superintendent United States Coast and Geodetic Survey.

CIRCULATION OF THE SEA THROUGH NEW YORK HARBOR.

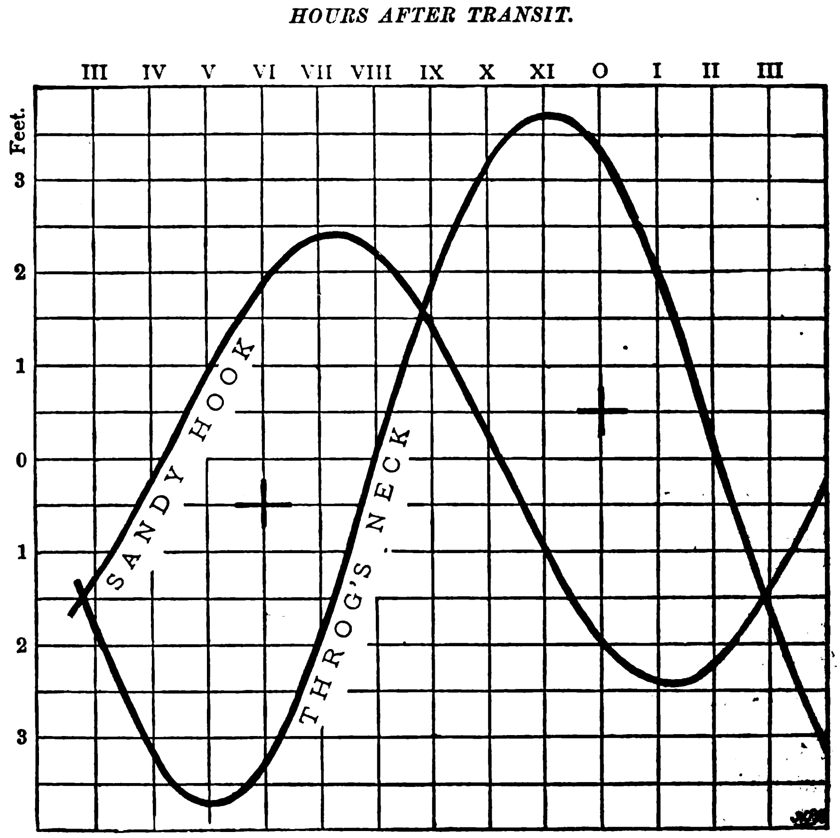
Although the tidal currents of New York, especially in the East River, appear to move to and fro, with ebb and flood, in monotonous repetition, like the swing of the pendulum, there is a *net gain*, under ordinary conditions of river discharge, to the westward, *i. e.*, a permanent transfer of water from the Sound through the harbor and out into the ocean over Sandy Hook Bar. This statement, if true, involves so many consequences affecting the condition of the harbor (its navigation and its improvement) that I have put it in the form of a proposition to be demonstrated, *first*, from the most general relations of the Sound and Harbor tides as oscillations of the sea "interfering" at Hell Gate; and *second*, from a strictly inductive study of gaugings made by different observers at different dates. I shall first show that it *ought to be true* theoretically and then show that *it is true* practically.

General relations of the tides.—Two derivations of the tide enter New York Harbor; one by way of Long Island Sound, the other by way of Sandy Hook Bar. The one that traverses the Sound is much obstructed and crowded, so that it arrives upon the scene four hours behind the other, and much augmented in range. These two tides meet or pass into each other at Hell Gate, and give to the city portion of the East River a composite *rise and fall*, and to the whole length of the strait a nearly synchronous system of tidal currents.

As types of the two tidal profiles, as they appear before their meeting and before they affect each other in their approach, we offer the diagram (A) that follows:

No. 34

DIAG. A.



TYPES OF THE TIDAL PROFILES.

The two figures are serpentine curves whose elements are those of the tides given in the tables of published charts for the two entrances to New York. From this diagram we observe that about three lunar hours after the moon's transit the surface of the Sound is at the same elevation as the sea at Sandy Hook. Later they differ, and more and more widely, till at the sixth hour a maximum difference of height is reached which exceeds 5 feet. Then a decline takes place, till at the ninth hour the Sound and Sandy Hook Bay are again upon the same level. After this a slope in the opposite sense develops, reaching a maximum about the time of the next transit. The first slope, that between three hours and nine, is towards the Sound, *i. e.*, the Sound continues through this interval to be lower than the Harbor. The second slope is towards the Harbor, and one may remember it easily as that which reaches its maximum at the *southing-of-the-moon*, and creates the "ebb current," so-called. The peculiar quality of the East River current, as compared with the *free tidal current* is that the former is a gravity stream, *i. e.*, it is water running down a slope as in a fresh-water river. Referring again to the diagram, it will be seen that the two lunes, or spaces between the type-curves, are equal, *i. e.*, the *slopes*, creating the flood-current and the ebb-current alternately, are equal in amount and duration. There is the same head for one stream as for the other. But there is a very important difference in the positions of these lunes, which affects materially the relative values of the *slopes* they represent. We have marked with a cross the center of each, and it will be observed that the right-hand lune is 1 foot above the other, which means

that the ebb (westerly) current is in deeper water and greater transverse section than the flood. It is, therefore, the larger stream, and, having greater *hydraulic mean depth*, it is the quicker also. The East River is delivering more water into New York Harbor than it carries back again to the Sound.

Although the Hudson and other rivers flow into New York Harbor, and slightly raise its level, the conditions illustrated in our diagram are very nearly realized in the seasons when the fresh-water discharge is at a minimum. One of these seasons is the autumn; the other is mid-winter, when the land-waters are ice-bound. At such times the greater velocity being westward, and the greater depth of water being that of the westerly flow, there is, as a *net result*, a cirulation of sea-water through the harbor from the Sound to the ocean. In mid-winter this circulation renewing the water before it can get chilled, and lowering the freezing point by mixing sea-water with the river discharge, serves to keep the port open to commerce. One may form some estimate of the value of the four degrees difference of the freezing points between sea and river waters, when it is remembered that in severe winters Halifax, Portland, and Boston have not closed before Philadelphia or even Baltimore.

This circulation also aids in maintaining the channels over the bar, which could not exist if the ebb and flood were equal, *i. e.*, if there were no net gain of the sands swept to and fro. For the bar is but a broken portion of the *cordon littoral* of which Sandy Hook and Coney Island are dry parts. Its channels are maintained by a slight preponderance of the seaward flow, as our observations distinctly show.

The indirect value of this influx from the Sound during the dry season lies in the partial supply of the *under-run* of sea-water which occurs when the head of the river is insufficient to counterbalance the greater density of the sea-water. We do not find this *under-run* (or preponderance of inflow) at higher levels than the deepest channel-beds of the bar, except on rare occasions; but one may easily see that the withdrawal of the influx from the Sound would cause the bar to rise and work inward. The fresh waters, that enter from the Hudson and other streams, play an insignificant part in the physics of the harbor; but the circulation of the sea by way of the East River, although small in quantity, is the element which determines the superiority of New York Harbor over nearly all the sand-barred inlets of the world. It is this circulation which keeps the port open in winter and sweeps the sand from its threshold.

FIELD WORK OF 1886.

Before entering upon detailed illustrations of the relation between slope and velocity, as revealed by the past season's work, it may be well to state how it happened that this theme came to be pursued by the field and office parties instead of the gauging of the bar originally contemplated. In order to properly gauge the bar and to ascertain whether the channels over it are hollowed out of the sands to the limit of *resultant scour*, it was foreseen that two steam launches would be required, besides the other vessels, and Congress was asked to appropriate money for these, but did not; and finding that the launches already in the possession of our service were either unfit or unavailable for this special use, we abandoned our project and sought other ends within our means.

Mr. Henry L. Marindin, Assistant in the Coast and Geodetic Survey, was instructed by you to take charge of the field work, and furnished by me with "memoranda" setting forth the objects in view and the means of reaching them. He was directed, in effect, to occupy as many tidal and current stations *simultaneously* as could possibly be done, that "the relations of different basins and channels to the tidal system" might be disclosed; and "that the comparative value of different reservoirs and the particular office of each channel" might be determined, especially as affecting the draught of water over the bar. Moreover, he was directed to gather the material for a series of contour maps of the surface of the harbor—a long-cherished project.

In order that the computation should keep pace with the field work as nearly as the proper course of the latter might require, I secured an office for myself and my assistant (Mr. E. E. Haskell, an expert observer, formerly in the service of the Mississippi River Commission), and in this way mere routine was avoided, and all worked together with definite and direct purpose.

When everything had been prepared by Mr. Marindin to the utmost extent of his means, it was discovered that our special survey of the East River circulation, which was the salient point in our new project, required more experts and more vessels than we had provided. At this critical moment the Hydrographic Inspector, Lieut. Commander W. H. Brownson, U. S. N., with your consent, tendered assistance from the naval surveying parties at work in the neighborhood, and the whole thing was very successfully arranged. The interval between 8 a. m. of the 4th of October and 1 p. m. of the 7th, *i. e.*, over three entire days, was secured without a break at eleven tidal stations and four current stations. Mr. Marindin directed the tidal stations, going around to give them exact time, &c. He also in a general way kept the current station at Twenty-third street advised, while Lieut. G. C. Hanus, U. S. N., assisted by Ensign C. S. Ripley, U. S. N., occupied stations in the Narrows and on the Bar, and Lieut. C. P. Perkins, U. S. N., occupied a station off Old Ferry Point. The station depended upon especially for the East River flow was that at Twenty-third street, which had been occupied the previous year as a gauging section. At this station Mr. J. E. McGrath, of our own service, and Mr. Homer P. Ritter (an expert observer formerly in the service of the Mississippi River Commission), made the observations, assisted by Mr. George E. Kent, who also acted as sailing master. At the close of the season Mr. McGrath, assisted by Mr. Ritter, ran lines of precise levels connecting Hunter's Point, Ravenswood, Eighty-fourth street, Pot Cove, Polhemus, College Point, and Willets Point tide gauges with repetitions and checks removing all doubts. All of the stations proved to have the same *mean level* except Pot Cove, where the surface near time of low water appears to be lifted above where it should be. It may be that the great whirl from which the cove gets its name really creates this local elevation during the strength of the flood (easterly) current. We have not dared use this station in computing *slopes*, because, even if the levelings and observations are without error, the results are not in accord with the uniform testimony of other stations.

Since, with this single exception, the stations connected by precise levels proved to have the same mean sea-level, it was assumed that Governor's Island and Sandy Hook had the same; so that the falling short of our level lines has not distressed us thus far. Nevertheless it is very important that the precise levels should be extended to Governor's Island and to stations on the Lower Hudson. And it is at least *very desirable* to have the levels extended to the Narrows on the Long Island side, to the head of Newark Bay, through the Kills, around the Sandy Hook Bay to Sandy Hook light-house, connecting *en route* with all the tide gauges and making benches of the datum-planes of all the light-houses, forts, &c. We anticipate the *necessity* for these lines at an early date.

The foregoing is a sufficient résumé of that portion of the field work of the past season which has supplied data for what follows in the discussion of the circulation. I refrain from any mention of the water contours in the harbor, because Mr. Marindin is working up these, and will present the whole scheme in a series of charts for which the office has supplied the skeletons.

It is not often that I feel content with my data; but this time we seem to have foreseen our wants, and by keeping office work and field work together or in concert, we have filled out the requisition.

TABLE 1.—*Field work, season of* 1886.

[Party of H. L. Marindin, Assistant, Coast and Geodetic Survey.]

Locality of tide staff.	Time occupied. From—	Time occupied. To—	Number of readings.	Names of observers.
	1886.	1886.		
Sandy Hook, N. J. (Lower Bay).	Sept. 21	Oct. 30	3, 862	J. Gundersen, G. T. Bartlett, M. J. O'Connor, and Fred. E. Nilson.
Governor's Island (Upper Bay).	Sept. 27	Oct. 30	3, 966	G. F. Simpson, W. D. Buckout, and H. E. Pearce.
Willets Point, Long Island (East River).	Oct. 4	Oct. 30	3, 293	O. M. Gjertsen; Ochr. Ribe.
Dobbs Ferry (Hudson River).	Sept. 27	Oct. 30	4, 577	R. G. G. Moldenke; W. G. E. Schultz.
Lower Bay:				
Bath, Long Island.	Sept. 21	Sept. 25	603	H. W. and W. L. Dusenberry.
Great Kills, Long Island.	Sept. 21	Sept. 26	698	R. G. G. Moldenke; W. G. E. Schultz.
South Amboy, N. J.	Sept. 21	Sept. 25	547	Ernest J. Lederle; Epenetus Howe.
Conaskonk Point, N. J.	Sept. 22	Sept. 25	396	M. J. O'Connor; Fred. E. Nilson.
Port Monmouth, N. J.	Sept. 22	Sept. 25	489	H. Christensen; O. M. Gjertsen.
Quarantine Dock (Narrows).	Sept. 21	Sept. 25	597	G. F. Simpson; W. D. Buckout.
Upper Bay:				
Quarantine Dock (Narrows).	Sept. 27	Oct. 1	536	E. J. Lederle; Epenetus Howe.
Bay Ridge, Long Island.	Sept. 27	Oct. 1	589	H. Christensen; O. M. Gjertsen.
Constable's Hook, N. J.	Sept. 29	Oct. 1	307	J. J. Ormsbee; H. E. Pearce.
Forty-second street (Hudson River).	Sept. 28	Oct. 1	427	Geo. F. Bartlett; J. Gundersen.
East River:				
Corlear's Hook, N. Y.	Oct. 2	Oct. 7	701	H. Christensen; Peter Shelley.
Hunter's Point, Long Island.	Oct. 2	Oct. 7	669	E. Howe; J. Cameron.
Ravenswood, Long Island.	Oct. 2	Oct. 7	693	E. J. Lederle; Alfred Cockerill.
Eighty-fourth street (East River).	Oct. 2	Oct. 7	690	J. Gundersen; J. Sullivan.
Pot Cove.	Oct. 2	Oct. 7	710	J. J. Ormsbee; T. A. Masterson.
Port Morris.	Oct. 3	Oct. 7	610	Geo. F. Bartlett; Ch. Lyon.
Polhemus Dock.	Oct. 2	Oct. 6	587	Wm. Tayler; J. Petersen.
College Point.	Oct. 2	Oct. 7	709	H. E. Pearce; W. H. Martin.
Whitestone Landing.	Oct. 1	Oct. 3	261	H. W. and W. L. Dusenberry.
Newark Bay and Kills:				
South Amboy, N. J.	Oct. 11	Oct. 14	443	J. Gundersen; H. Christensen.
Elizabethport, N. J.	Oct. 11	Oct. 14	459	T. A. Masterson; J. J. Ormsbee.
Elm Park, Staten Island.	Oct. 11	Oct. 14	447	J. Sullivan; Alfred Cockerill.
Hackensack River Bridge.	Oct. 11	Oct. 14	428	J. Cameron; I. Doughty.
Quarantine Dock (Narrows).	Oct. 11	Oct. 14	423	W. H. Martin; Ch. Lyon.
Forty second street (Hudson River).	Oct. 11	Oct. 14	434	James Petersen; Wm. Tayler.

TABLE 1.—*Field work, season of* 1886—Continued.

Locality of current stations.	Number of current observations.	Number of sextant angles.	Vessel.	Observers.
Off Twenty-third street (East River).	308	328	Schr. Ready.	J. E. McGrath, Subassistant, Coast and Geodetic Survey; Homer P. Ritter, and G. E. Kent.

RECAPITULATION.

Number of tide-gauges observed	25
Number of observations recorded	29,151
Number of current observations recorded	308
Number of sextant angles recorded	328

TABLE 2.—*Current observations, taken by the naval parties on October* 4, 5, *and* 6, 1886.

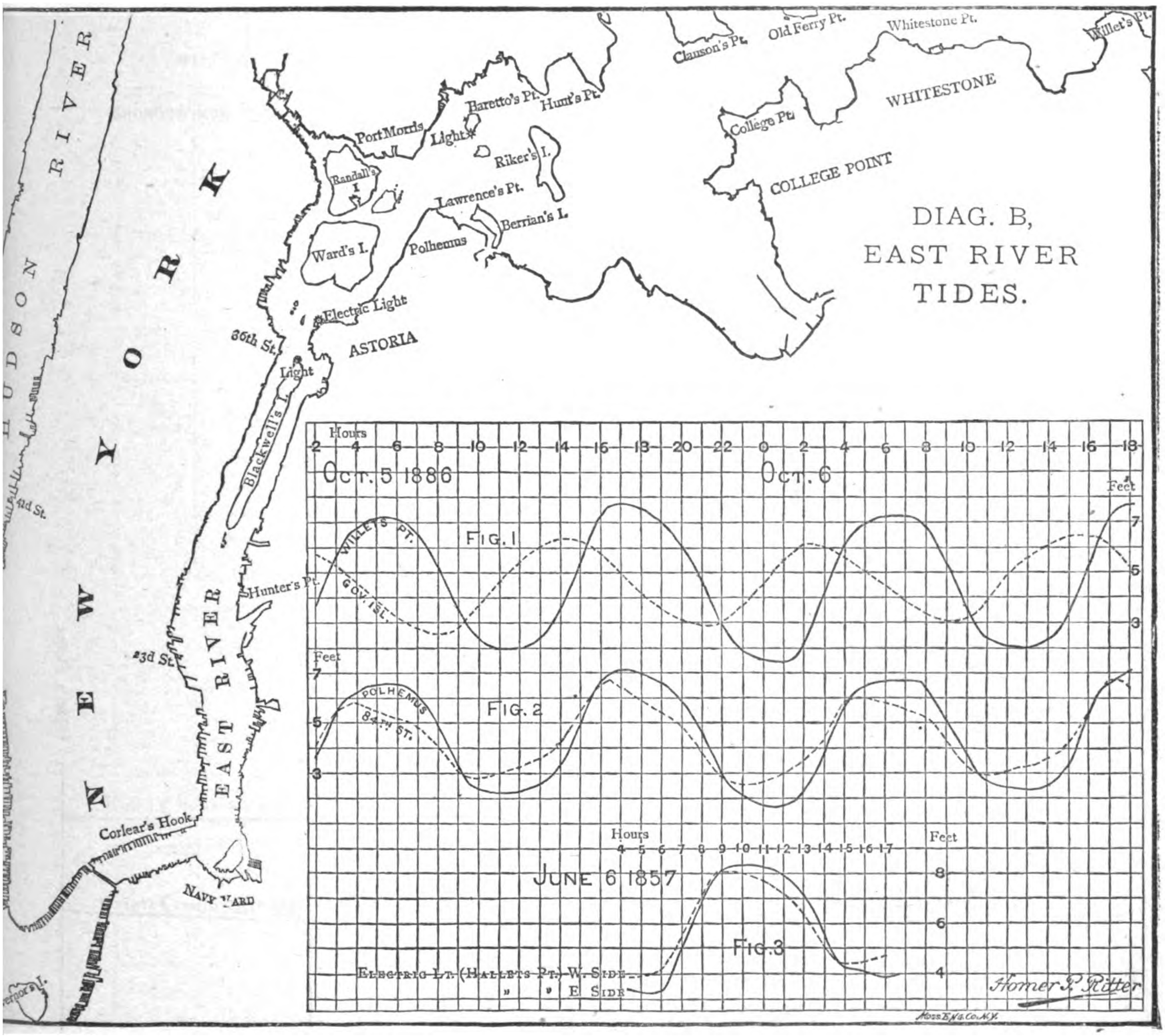
Location of current station.	Number of current observations.	Number of sextant angles.	Wind, tide, temperature, barometer, and other observations.	Observers.
Off Old Ferry Point, East River, U. S. Coast and Geodetic Survey schooner Eagre, C. P. Perkins, lieutenant U. S. N., Assistant U. S. Coast and Geodetic Survey, commanding.	233	150	474	Lieut. C. P. Perkins, U. S. N., commanding; Ensign W. B. Fletcher; Mr. W. Heinsheimer.
In the Narrows, New York Harbor, U. S. Coast and Geodetic Survey steamer Daisy, G. C. Hanus, lieutenant U. S. N., Assistant U. S. Coast and Geodetic Survey, commanding.	221	277	871	Ensigns C. S. Ripley and N. W. Jones, U. S. N.
In East Channel, Lower Bay, New York Harbor, U. S. Coast and Geodetic Survey steamer Endeavor, G. C. Hanus, lieutenant U. S. N., Assistant U. S. Coast and Geodetic Survey, commanding.	220	324	609	Lieut. G. C. Hanus, U. S. N., commanding, and Ensign E. F. Leiper, U. S. N.

EAST RIVER TIDES AND TIDAL CURRENTS.

In illustration of the relations of the two derivations of the tide that meet at Hell Gate we offer Diagram B drawn by Mr. Ritter. The first figure exhibits the profiles of the tides at Governor's Island and Willets Point—the stations that lie at the extremities of the strait connecting Long Island Sound with New York Harbor; the second figure shows the profiles of the same tides within a mile of their meeting place; and the third figure the same tides at the very *sill* of the Gate just prior to their meeting.

The first and second figures are from synchronous observations, and two other pairs of profiles might have been plotted over these but for the confusion of lines; for we have eight stations of faultless tidal observations besides two current stations in the East River for the 4th, 5th, and 6th of October, 1886. (See schedule of field work preceding.)

The third figure of Diagram B is plotted from observations made long ago (1857) before Hallet's Reef was blasted away.



It will be observed that these curves, which are plotted above and below an axis representing the mean level of the sea, make two intersections, one about three, another about nine hours after the southing of the moon. These intersections mean that the two water surfaces which the curves represent are then at the same absolute level; and if all the pairs of stations throughout the strait were to intersect at the same moment, we should say that at that moment the whole flat surface of the strait from Harbor to Sound lies at the same level. This is nearly the case, but not quite. There is an unequal loss of time in approaching the Gate from different directions which brings about distinct intersections among our plotted profiles, and as this involves loss of time it involves also changes of elevation. Mr. Haskell has prepared for me Table 3 and Diagram C, which follow, giving the nearest approach to the horizontal water surface and the widest departure rom it:

TABLE 3.—*Lunar intervals of upper and lower restorations of level between Governor's Island and Willets Point, with synchronous heights at other stations from eight tides, October 4 to 6, 1886.*

[Computed by E. E. Haskell.]

Level.	Lunar interval.	Governor's Island or Willets Point.	Corlear's Hook.	Hunter's Point.	Ravenswood.	Eighty-fourth street.	Polhemus Dock.	College Point.
	h. m.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Upper.	9 08	5.88	5.88	5.72	5.72	5.71	5.63	5.71
Lower.	3 07	2.93	2.98	2.72	2.74	2.87	2.85	2.91

Time after transit of maximum fall between Governor's Island and Willets Point, with synchronous gauge readings at all stations from eight tides, October 4 to 6, 1886.

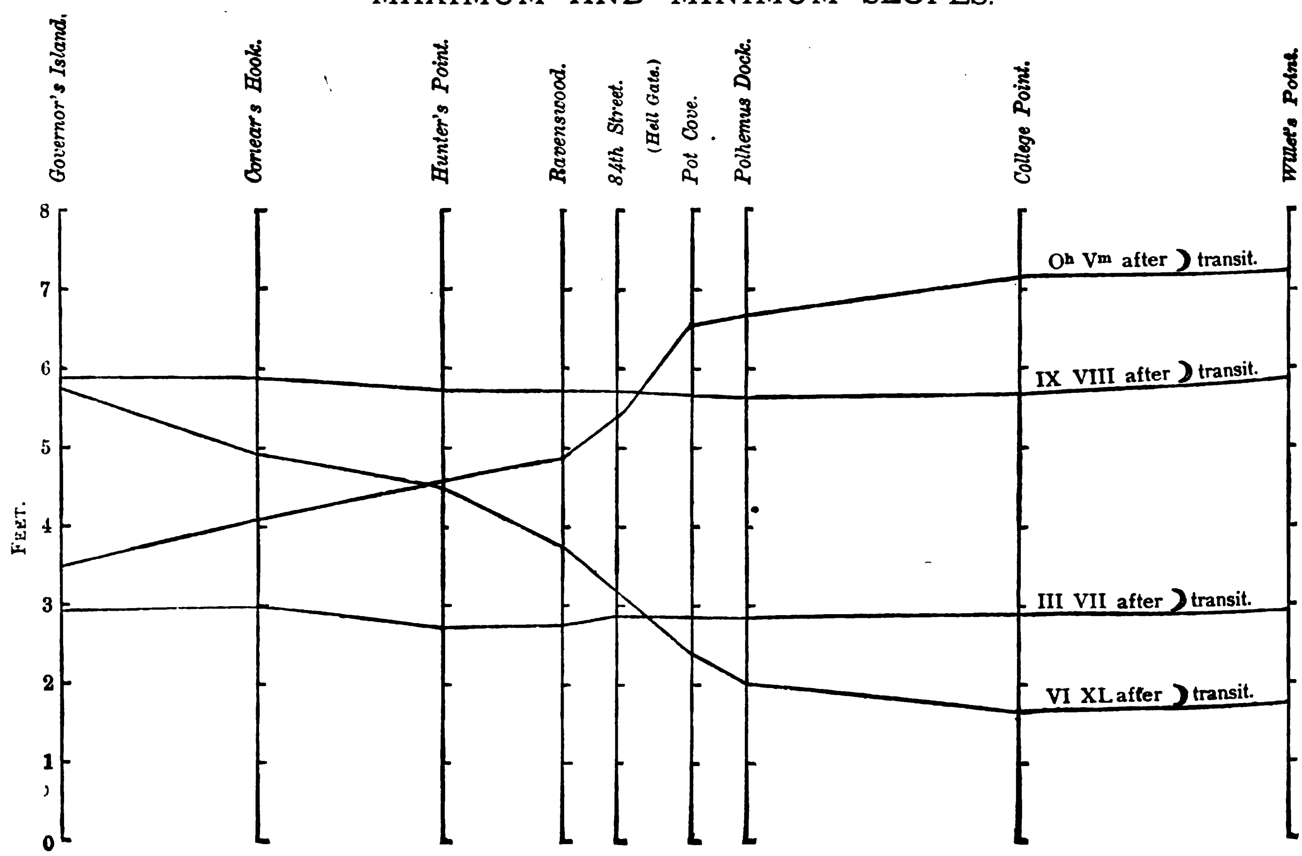
Tide.	Lunar interval.	Governor's Island.	Slope.	Corlear's Hook.	Slope.	Hunter's Point.	Slope.	Ravenswood.	Slope.
	h. m.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Ebb.	0 05	3.48	0.58	4.06	0.51	4.57	0.30	4.87	0.54
Flood.	6 40	5.74	0.82	4.92	0.42	4.50	0.73	3.77	0.60

Tide.	Lunar interval.	Eighty-fourth street.	Slope.	Polhemus Dock.	Slope.	College Point.	Slope.	Willets Point.	Maximum slope.
	h. m.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Ebb	0 05	5.41	1.28	6.69	0.48	7.17	0.08	7.25	3.77
Flood.	6 40	3.17	1.16	2.01	0.36	1.65	0.09	1.74	4.00

No. 36

DIAG. C.

MAXIMUM AND MINIMUM SLOPES.



It has already been stated that the restorations of level are not exactly synchronous from station to station; for this reason the planes whose profiles appear at III[hrs] and at IX[hrs] in Diagram C are warped. The discrepancies are too small to confuse the simple conception with which this paper opened; but we take the precaution to give these discrepancies as tabulated by Mr. Bradford and Mr. Haskell in the tables that follow (4 and 5).

TABLE 4.—*Comparison of restorations of level.*

[Computed by G. Bradford, Assistant Coast and Geodetic Survey.]

WILLETS POINT AND GOVERNOR'S ISLAND: POLHEMUS DOCK AND EIGHTY-FOURTH STREET.

Date.	Moon's transit, 75° time.	Luni-tidal interval, upper restoration.		Difference.	Luni-tidal interval, lower restoration.		Difference.	Heights, upper restoration.		Difference.	Heights, lower restoration.		Difference.
		Willets Point to Governor's Island.	Polhemus Dock to Eighty-fourth street.		Willets Point to Governor's Island.	Polhemus Dock to Eighty-fourth street.		Willets Point to Governor's Island.	Polhemus Dock to Eighty-fourth street.		Willets Point to Governor's Island.	Polhemus Dock to Eighty-fourth street.	
1886.	*h. m.*	*h. m.*	*h. m.*	*m.*	*h. m.*	*h. m.*	*m.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Oct. 4	5 26	9 09	9 18	—09	------	------	------	6.06	6.14	—0.08	------	------	------
	17 51	8 58	9 04	—06	2 57	2 49	+08	5.35	5.36	—0.00	2.54	2.64	—0.10
5	6 16	9 09	9 41	—32	3 03	2 58	+05	6.15	6.52	—0.37	2.98	2.98	0.00
	18 40	9 08	9 35	—27.	3 16	3 19	—03	5.77	6.02	—0.25	3.02	2.83	+0.19
6	7 02	9 22	9 28	—06	3 11	3 34	—23	6.36	6.33	+0.03	3.27	2.98	+0.29
Mean difference.			------	—16	------	------	—03	------	------	—0.13	------	------	+0.10

WILLETS POINT AND GOVERNOR'S ISLAND: POLHEMUS DOCK AND RAVENSWOOD.

Date.	Moon's transit, 75° time.	Luni-tidal interval, upper restoration.		Difference.	Luni-tidal interval, lower restoration.		Difference.	Heights, upper restoration.		Difference.	Heights, lower restoration.		Difference.
		Willets Point to Governor's Island.	Polhemus Dock to Ravenswood.		Willets Point to Governor's Island.	Polhemus Dock to Ravenswood.		Willets Point to Governor's Island.	Polhemus Dock to Ravenswood.		Willets Point to Governor's Island.	Polhemus Dock to Ravenswood.	
1886.	*h. m.*	*h. m.*	*h. m.*	*m.*	*h. m.*	*h. m.*	*m.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Oct. 4	5 26	9 09	9 04	+05	------	------	------	6.06	5.90	+0.16	------	------	------
	17 51	8 58	9 03	—05	2 57	2 59	—02	5.35	5.32	+0.03	2.54	2.32	+0.22
5	6 16	9 09	9 18	—09	3 03	3 07	—04	6.15	6.17	—0.02	2.98	2.75	+0.23
	18 40	9 08	9 22	—14	3 16	3 21	—05	5.77	5.78	—0.01	3.02	2.78	+0.24
6	7 02	9 22	9 31	—09	3 11	3 30	—19	6.36	6.40	—0.04	3.27	3.01	+0.26
Mean difference.			------	—06	------	------	—07	------	------	+0.02		------	+0.24

TABLE 5.—*Maximum slope (by reaches) of the East River, October 4 to 6, 1886.*

[Computed by E. E. Haskell.]

Date.	75° time.	Governor's Island to Eighty-fourth street.		Eighty-fourth street to Polhemus Dock.		Polhemus Dock to Willets Point.		Time after moon's transit.	Remarks.
		Flood slope.	Ebb slope.	Flood slope.	Ebb slope.	Flood slope.	Ebb slope.		
		MAXIMUM.							
1886.	*h. m.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*h. m.*	
Oct. 4	18 50	......	2.16	......	0.59	......	0.40	0 59	
5	0 30	2.79	......	1.16	......	0.35	......	6 39	
	6 40	......	2.22	......	1.33	......	0.55	0 24	
	13 00	2.33	......	1.04	......	0.22	......	6 44	
	19 20	......	1.86	......	1.13	......	0.49	0 40	
6	1 30	2.72	......	1.34	......	0.15	......	6 50	
	7 40	......	1.95	......	1.17	......	0.59	0 36	
	13 30	2.52	......	0.97	......	0.32	......	6 26	
Means.		2.59	2.05	1.13	1.05	0.26	0.51	Ebb 0 40 Flood 6 40	After transit.
				MAXIMUM.					
Oct. 4	17 30	......	1.81	......	1.39	......	0.52	12 03	
5	0 50	2.73	......	1.21	......	0.21	......	6 59	
	6 30	......	2.16	......	1.42	......	0.55	0 14	
	13 10	2.30	......	1.10	......	0.14	......	6 54	
	19 00	......	1.83	......	1.21	......	0.52	0 20	
6	1 20	2.68	......	1.37	......	0.20	......	6 40	
	7 30	......	1.85	......	1.27	......	0.58	0 26	
	13 50	2.44	......	1.09	......	0.30	......	6 46	
Means.		2.54	1.91	1.19	1.32	0.21	0.54	Ebb 0 10 Flood 6 50	After transit.
						MAXIMUM.			
Oct. 4	16 40	......	1.54	......	1.01	......	0.57	11 13	
	23 00	1.89	......	0.65	......	0.45	......	5 09	
5	5 50	......	1.93	......	1.36	......	0.66	11 59	
	11 40	1.93	......	0.92	......	0.30	......	5 24	
	18 30	......	1.79	......	1.08	......	0.70	12 14	
	23 10	1.24	......	0.39	......	0.38	......	4 30	
6	5 10	......	1.09	......	0.32	......	0.66	10 30	
	11 20	1.26	......	0.35	......	0.38	......	4 16	
Means.		1.58	1.58	0.58	0.94	0.38	0.65	Ebb 0 55 Flood 4 50	Before transit. After transit.

The absolute height, irrespective of time, at which the intersections among our plotted profiles occur is essentially the same for our different pairs of stations, notwithstanding that we have had little choice in making these pairs—the stations having been located under restrictions of convenience somewhat.

In Tables 6 and 7, which follow, the restorations and mean slopes are tabulated for a whole lunation, that the variations for the moon's age, declination, &c., may be exhibited. The variation with transit, *i. e.*, the half-monthly inequality, is much like that of high water and low water, but we discover no orderly variation with declination, and upon this point we shall have something to say hereafter.

TABLE 6.—*Comparison of slopes, Governor's Island – Willets Point.*

[Computed by G. Bradford.]

Date.	Restoration of level.		Mean slope.		Date.	Restoration of level.		Mean slope.	
	Upper.	Lower.	Westerly.	Easterly.		Upper.	Lower.	Westerly.	Easterly.
1886.	*h. m.*	*h. m.*	*Feet.*	*Feet.*	1886.	*h. m.*	*h. m.*	*Feet.*	*Feet.*
Oct. 4	14 35	20 48	2.45	2.55	Oct. 18	0 15	6 20	2.81	2.79
5	2 49	9 19	2.63	2.44		12 30	18 57	3.26	2.48
	15 25	21 56	2.41	2.46	19	1 07	7 14	2.97	2.97
6	3 48	10 13	2.30	2.57		13 25	19 39	2.56	2.89
	16 24	22 59	2.39	2.32	20	1 51	8 10	2.68	3.02
7	4 50	11 15	2.23	2.42		14 25	20 44	2.47	2.84
	17 20	23 50	2.49	2.51	21	3 05	9 12	2.79	3.03
8	5 57	12 07	2.05	2.90		15 29	22 12	2.64	3.18
	18 27	--------	--------	--------	22	3 56	10 32	2.66	3.14
9	6 38	0 30	2.43	2.81		16 40	23 07	2.83	3.22
	19 08	12 55	2.77	2.73	23	5 07	11 43	3.29	3.44
10	7 14	1 14	2.87	2.85		17 40	--------	--------	--------
	19 45	13 32	2.70	3.17	24	6 04	0 22	3.61	3.30
11	7 54	1 50	3.15	3.06		18 42	12 41	3.50	3.74
	20 17	14 12	2.91	3.39	25	7 07	1 09	3.34	3.80
12	8 30	2 30	3.19	3.12		19 37	13 38	3.47	4.07
	20 46	14 50	2.87	3.32	26	7 55	2 00	3.85	3.95
13	9.02	3 06	3.05	3.08		20 22	14 32	3.53	4.20
	21 15	15 28	3.50	3.21	27	8 40	3 05	3.69	3.51
14	9 45	3 43	3.15	3.34		21 11	15 38	4.23	2.98
	21 55	15 55	3.08	3.42	28	9 36	3 40	3.70	4.00
15	10 18	4 20	2.89	3.22		22 00	16 00	3.72	4.00
	22 51	16 36	2.81	3.11	29	10 27	4 19	3.70	3.80
16	11 05	4 46	3.12	2.90		22 48	16 47	3.79	3.50
	23 23	17 38	2.96	3.15	30	--------	5 08	3.27	--------
17	11 35	5 28	2.97	2.91	Means	--------	--------	3.02	3.14
	--------	17 53	3.19	2.99					

	h.	*m.*
Duration of westerly slope	6	23
Duration of easterly slope	6	02

TABLE 7.—*Intervals and heights of restoration of level between New York Harbor (Governor's Island) and Long Island Sound (Willets Point), from observations made in October, 1886.*

[Computed by H. Mitchell.]

Transit time.	Restoration of level. Upper. Intervals.	Restoration of level. Upper. Heights.	Restoration of level. Lower. Intervals.	Restoration of level. Lower. Heights.	Moon's declination.	
0	*h. m.*	*Feet.*	*h. m.*	*Feet.*	°	
½	9 04	7.30	3 10	2.47	11	
I						
½	8 57	7.12	2 55	2.57	14½	
II						
½	8 51	5.70	2 48	2.18	17	Only one set of observations.
III						
½	8 34	6.60	2 26	2.48	18½	
IV						
½	8 43	6.06	2 30	2.55	19	
V						
½	8 47	6.07	2 35	2.74	18½	
VI						
½	8 55	5.77	2 50	2.70	17	
VII						
½	9 06	5.99	3 11	2.49	15	
VIII						
½	9 24	6.43	3 22	2.48	12	
IX						
½	9 27	6.50	3 27	2.27	6	
X						
½	9 24	6.71	3 21	2.11	0	
XI						
½	9 12	6.92	3 17	2.04	5	
Means.	9 02	6.43	2 59	2.42	--------	

The average difference between the *stages* for the two slopes has been very carefully computed for me by Mr. Ritter for the entire lunation of observations at Governor's Island and Willets Point. It proves to be 1.48 feet, or just about one-half the mean slope, and could not have been otherwise if our stations represent, as we assume, the two ends of the strait in which such slopes are found In Diagram C, in which the slopes are plotted for certain days and hours, we see a reversion point of the slope just below Hunter's Point at the time when the maximum difference of surface level obtains between Governor's Island and Willets Point. In treating mean slopes, we find it possible to trace the difference of stage as far as Corlear's Hook, between which and Hunter's Point, the ebb and flood, with nearly equal slopes (0.31 foot westerly and 0.29 foot easterly), lie very nearly at the same stage, the ebb being less than 0.01 of a foot higher. But the duration of the easterly slope exceeds that in the opposite direction, at least when plotted by mean levels. Referring again to Diagram B, it will be seen that the *lunes* made by the intersecting curves are not all of the same size. As we approach the Gate we see them diminish; this means that the two tides are reconciling their differences. Instead of making a vertical fall at Hell Gate, as our Diagram A seemed to threaten, the "*head*" falls back by an actual transfer of water. The "*head*" is not

absolutely inexhaustible, in the sense that our opening scheme conveniently assumed. It is a question, then, whether the artificial enlargement of the "section" at Hell Gate can materially quicken the mean rate of flow, as one might expect in the case of an exhaustless "*head*." The falls given in Table 3 are the ordinates of all the lunes at the moment of greatest difference of surface level between Governor's Island and Hallet's Point, and these "falls" diminish from about 4 feet between extremes to about 1 foot within the tumult of Hell Gate; but the slopes become more and more steep. It is a very curious fact that the harbor tides seem to suffer more depletion, when high, and more filling-in, when low, than the Sound tides. The Sound tide scarcely indicates interference till it reaches Hallet's Point, whereas even Governor's Island tide betrays in its profile the presence of oscillations from the Sound.

From the preceding tables and diagrams it will be seen that the level of the East River is restored three hours (2^h 59^m) after the transit of the moon at a stage 2 feet below the mean sea-level. An easterly slope (and flood current) then develops, reaching a maximum of 4.7 feet at the sixth hour after transit and declining to zero again at the ninth hour (9^h 02^m). The mean of this easterly slope is 3.14 feet and its duration 6^h 02^m. This restoration occurs at a stage 2 feet above the mean sea-level. A westerly slope then develops (with ebb current), reaching a maximum of 4.8 feet at the hour of transit, and declines to zero about three hours later. The mean of this westerly slope is 3.02 feet and its duration 6^h 23^m. The integrals of slope are, then, essentially equal for the two directions; and the currents which these slopes excite would also be equal if the depth of water remained the same for each slope; but this is far from being the case. One has but to glance at the diagram to see that the lunes made by the overlapping profiles are at unequal elevations.

The actual *node* of the tide, *i. e.*, the transfer from one derivation to the other, occurs always at what is specifically known as the *Gate*, which is the narrow and obstructed turn off Hallet's Point. Here the establishment shifts two hours and the tidal ranges alter 15 per cent. in 200 feet. This particular statement is based upon observations made before the blasting of Hallet's Reef; but other stations of recent occupation within a few thousand feet bear the same or similar testimony. The last figure of our Diagram B is plotted directly from the note-books, and, while it does not strictly represent average conditions, it is typical of these. It will be observed that the two lunes in our figure are essentially equal, but very differently situated. The left-hand lune (which measures the slope eastward when the harbor is above the Sound) occurs at a stage 2 feet lower than the right-hand lune, which measures westerly slopes. In other words, when the slope is westward, and the current is flowing that way, there is a depth of water 2 feet greater than when the reverse slopes and currents prevail.

In the present condition of the Gate, a line drawn from the shore at the electric light to the opposite shore in a direction N. 35° E. (true) indicates a width of about 570 meters, one-fifth of which is interrupted by the Hog's Back Reef. As I remember the scene before the blasting was done, there was a noisy vertical fall over Hallet's Reef on the flood and a furious boiling around the Hog's Back. The flood current converged in midchannel and became almost a torrent, the measured velocity being from 8 to 9 feet per second. But on the ebb a much quieter scene presented itself. The tide had so risen that the Sound waters *welled* over all obstructions and occupied the whole width of the passage way. It is not the particular obstructions in Hell Gate that cause a tidal node there, but these obstructions fix that node so that it is not prone to shift its location from springs to neaps, &c., as does the node between the Atlantic and Bay of Fundy tidal systems at the southeastern approach to Massachusetts.

Although it is directly at Hell Gate that we are to apply the test of net discharge, our observations were necessarily made at convenient stations on either side of that bewildering scene, and we fortunately have a pair of stations at no great distance which for the period they cover are wholly above suspicion of local re-action. These stations are Polhemus Dock, 1 mile eastward of Hallet's Point, and Eighty-fourth street, one-half mile westward of the same point. From a portion of the observations at these stations the second figure of Diagram B was plotted, and the computations show that the slope westward creating the "ebb" current is 2.32 feet more elevated (*i. e.*, at a higher *stage*) than the *slope* eastward, but the integral *slope* is nearly the same in both directions. The mean slope westward (Eighty-fourth street, lower than Polhemus Dock) is 0.73 foot, with duration

$6^h\ 12^m$, while the mean slope eastward is 0.67 foot, with duration $6^h\ 17^m$. It will be observed that the difference of *stage* is three or four times the slope.

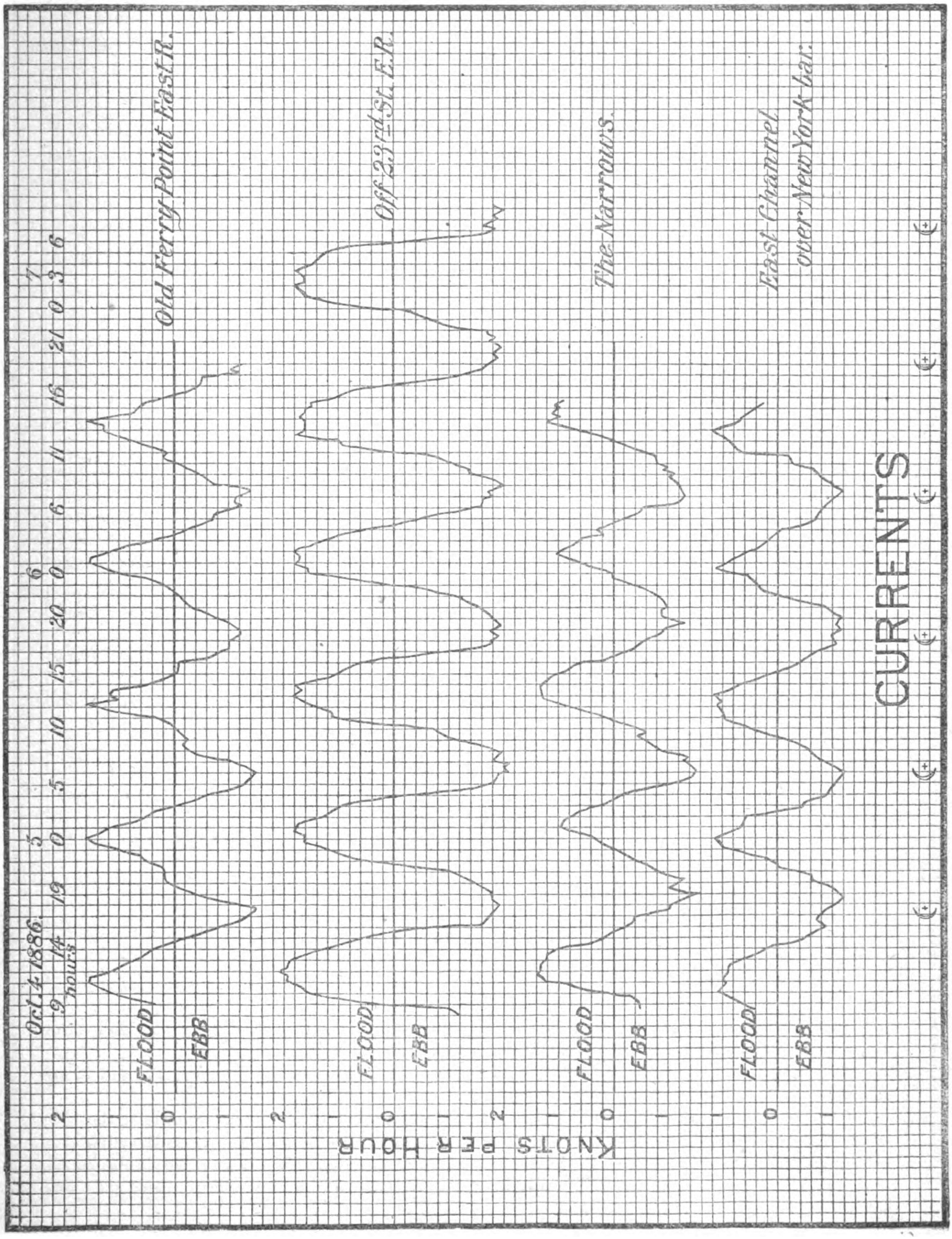
We have spoken of the slope westward as taking place at a stage 2.32 feet more elevated than the *slope* eastward, referring explicitly to the average during these *slopes*. If we inquire concerning the maximum slope the contrast of stage is much greater because the maximum *slope* westward is nearer the top of the tide in Hell Gate, while the maximum *slope* eastward is nearer the local time of low water.

From Table 3, and the Diagram B that illustrates it, one may estimate for the point intermediate between Eighty-fourth street and Polhemus Dock a difference of 3½ feet between the *stages* of alternate maximum *slopes*, *i. e.*, there are 3½ feet more water over the *sill* of Hell Gate when the western *slope* is at maximum than there is when the eastern slope is at maximum. We have reiterated the foregoing statement because it is the key-note of our theme and gives no uncertain sound. The city portion of the East River is *flushed* westward. We have indicated causes which should produce this effect, and now we purpose to prove our case by furnishing the observed process of actual discharge through the avenue.

During the period in which the tidal observations were being made along the East River and at Sandy Hook, the currents were also observed at two stations afloat in the East River, one in the Narrows and one on the Bar near the middle of the East Channel. These observations of currents have been plotted by Mr. Ritter from the field books, on diagram D, and below the figures the times of the moon's transits are indicated.

The first thing that strikes the eye in this diagram is the correspondence between the figures in time. Flood or ebb is a continuous stream from ocean to Sound at *strength*, and this strength, at ebb, falls very nearly at the time of the moon's transit; so that one can say that *at the southing-of-the-moon there is a continuous stream flowing from Long Island Sound through New York Harbor out over the bar to the ocean*, and at this time this ebb current is nearly at its *strength*. We are here at once reminded that it was at the southing-of-the-moon that we found the greatest *slope* between the Sound and the Harbor, and with this hint we proceed to connect the *slopes* and velocities more intimately together. That the success of this connection may be appreciated, attention must be called beforehand to the difficulty in selecting in any part of a tidal avenue a single station that will furnish an equally fair exhibit of ebb and flood; there is a proneness of these adverse streams to prefer opposite shores, and for obvious reasons as one looks at the approaches in contrast.

DIAG. D.


CURRENTS
KNOTS PER HOUR
Oct. 4 1886.
hours
Old Ferry Point East R.
Off 23rd St. E.R.
The Narrows.
East Channel
over New York bar.
FLOOD
EBB
FLOOD
EBB
FLOOD
EBB
FLOOD
EBB

No. 37

Two stations were selected, one on either side of Hell Gate, viz: "Off Twenty-third street" and "off Old Ferry Point," where gaugings for discharge had been made the season before. The comparison between the currents at these stations and the slopes of the East River are given in the tables which follow (8, 9, and 10):

VARIATIONS OF SLOPE AND VELOCITY.

TABLE 8.

[Computed by Homer P. Ritter, from three days' observations taken October 4 to 7, 1886.]

Lunar hours.	$1.9\sqrt{H}$, with 30 minutes' delay.	Observed current off Twenty-third street. (Feet per second.)	Residual.
0	2.95	3.04	+0.09
I	3.04	3.06	+0.02
II	2.58	2.58	0.00
III	1.67	1.67	0.00
½	0.93	0.90	−0.03
IV	1.26	0.76	−0.50
½	1.85	1.52	−0.33
V	2.24	2.24	+0.00
VI	2.88	2.94	+0.06
VII	3.16	2.84	−0.32
VIII	2.75	2.43	−0.32
IX	1.41	1.31	−0.10
½	0.81	0.51	−0.30
X	1.63	0.77	−0.86
½	2.05	2.05	0.00
XI	2.54	2.84	+0.30
0	2.91	3.11	+0.20

"H" = difference of heights of surface at Hunter's Point and College Point.

TABLE 9.

[Computed by E. E. Haskell, from three days' observations, October 4 to 7, 1886.]

Lunar hours.	Flood, $1.35\sqrt{H}$ Ebb, $1.55\sqrt{H}$ with 35 minutes' delay.	Observed current off Twenty-third street. (Feet per second.)	Residual.
0	2.85	3.15	0.30
I	2.97	3.15	0.18
II	2.65	2.60	−0.05
III	1.88	1.75	−0.13
IV	1.02	0.12	−0.90
V	2.01	2.09	0.08
VI	2.46	2.85	0.39
VII	2.68	2.80	0.12
VIII	2.38	2.39	0.01
IX	1.35	1.31	−0.04
X	1.62	0.65	−0.97
XI	2.45	2.84	0.39
0	2.85	3.15	0.30

"H" = difference of heights of surface at Governor's Island and Willets Point.

TABLE 10.

[Computed by E. E. Haskell, from three days' observations, October 4 to 7, 1886.]

Lunar hours.	0.5 (H)	Observed current off Old Ferry Point. (Feet per second.)	Residual.
0	1.87	2.12	+0.25
I	1.48	1.15	−0.33
II	0.97	0.36	−0.61
III	0.10	0.06	−0.04
IV	0.88	0.43	−0.45
V	1.45	1.51	+0.06
VI	1.93	2.34	+0.41
VII	1.85	1.94	+0.09
VIII	0.98	0.70	−0.28
IX	0.18	0.11	−0.07
X	1.09	1.09	0.00
XI	1.59	2.02	+0.43
0	1.87	2.12	+0.25

"H" = difference of heights of surface at Governor's Island and Willets Point.

In the foregoing tables the lunar hours are reckoned from the transit of the moon, and three days' simultaneous observations (ten or fifteen minutes apart) are used.

The better to convey the information of these tables, Diagram E, Figures 1, 2, and 3, are offered.

One who is acquainted with tidal currents easily recognizes in the discrepancies near the turn of the current familiar sources of difficulty in the process of observing. So long as the current is strong and runs fair with the channel the observations are consistent, but when the turn approaches, the vessel swings out from her old position, or the current takes a direction of which only one component lies in the previous train.

DIAG. E.

EAST RIVER,

No. 38

VARIATIONS OF SLOPE AND VELOCITY.

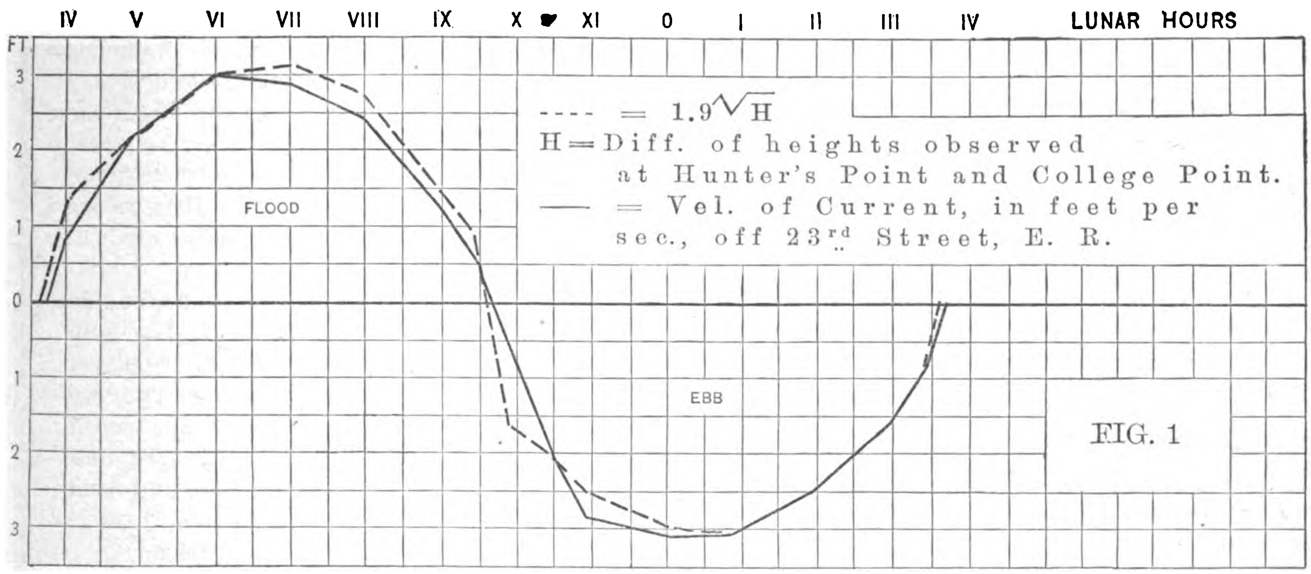


FIG. 1

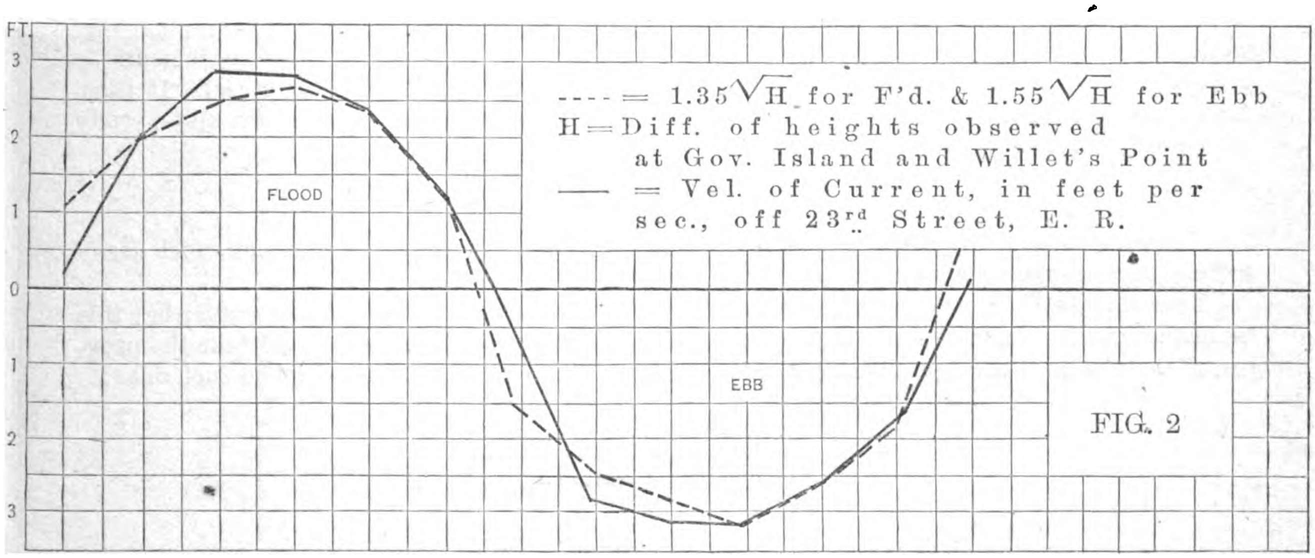


FIG. 2

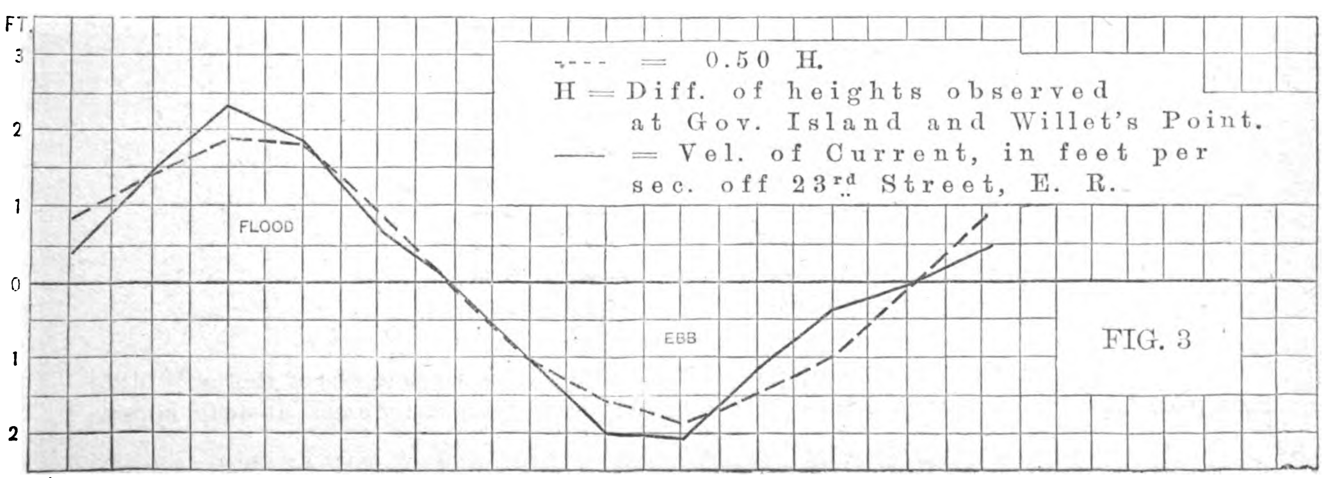


FIG. 3

If the epochs of *slack-water* and maximum velocity fall in properly with the times of restored level and maximum *slope*, I consider that cause and effect are established, and the constants of time and coefficients of velocity have *real* values. The coefficient of velocity is, of course, a local quantity, varying at every step along the course of the river, but the constant of time is the delay between cause and effect. The *slope* reverses before the current reverses—or, in other words, the current overruns. It is a measure of *inertia*.

If it be true that the currents of the East River are products of the *slope* in the most ordinary sense, as we have described, then the facts that these *slopes* occur at different *stages* in Hell Gate should necessitate greater discharge in the direction that the *highest stage slope* obtains, *i. e.*, west ward towards New York Harbor.

Previous to 1885 we had never attempted to gauge the East River except once, that was at Wall street in 1872. (See "The Harbor of New York; its Condition." New York Chamber of Commerce, 1873. Also, "Annual Report Coast and Geodetic Survey, 1871.")

I distinctly remember that it was a source of distress to us to find that no corrections for tide would balance ebb and flood at Wall street, and with such expert observers as Mr. H. L. Marindin and Mr. J. B. Weir, there was little chance of error; so we published the result with 42,000,000 of cubic feet excess of ebb (westerly) flow, and I referred to the discrepancy as perhaps an error of my own *reduction*. In 1885, however, we again gauged the East River at Old Ferry and "off Nineteenth street," sections nearly ten miles apart, and found an excess of ebb over flood of 432,000,000 and 448,000,000 cubic feet, respectively. In these gaugings, which were from shore to shore and from surface to bottom, Mr. Marindin was again in charge of the observers, and we had Messrs. Haskell and Ritter as expert observers detailed from the work of the Mississippi River Commission.

It is rare in physical studies that one is able, as in this instance, to connect cause and effect so intimately and prove the case from every point of view without discord anywhere; but this work in New York Harbor (done by patch-work with little money and wretched equipments as regards vessels) has had the advantage of first-rate observers and no ulterior object. It illustrates the value of a physical study made for the sake of anything that might turn up—a study whose only purpose was to find out what was going on.

MISCELLANEOUS.

There are several branches of my theme that are practically of little value, but which are of sufficient interest to bear brief notice.

I have spoken of the time of the tide as if it were represented by high and low water; but this is not the case in "*interferences*," where the profiles are distorted. Here we should take the progress of the middle of the figure, and in the following table Mr. Bradford has compiled such data:

TABLE 11.

Station.	Distance from Governor's Island.	Time after Governor's Island.
	Miles.	*h. m.*
Governor's Island.	0.0	0 00
Corlear's Hook.	2.3	0 53
Hunter's Point.	4.4	1 32
Ravenswood.	5.7	2 04
Eighty-fourth street.	6.4	2 40
Pot Cove.	7.2	3 22
Polhemus Dock.	7.9	3 24
College Point.	11.0	3 32
Willets Point.	14.3	3 26

Although the range of the tide at Sandy Hook is less than seven-tenths of that at Willets Point (0.65), the diurnal inequality is as great in the former as in the latter case. It would appear

that the experience of the tide propagated through the sound, as distinguished from the same tide presenting itself at the Sandy Hook entrance, is represented almost exclusively in the augmentation and retard of the semi-diurnal wave. The diurnal element, when evolved by the folding backwards and forwards in intervals of a half day each, proves to be much the same curve in either case. By the folding process just referred to and by the exercise of considerable ingenuity with "trial and error," Mr. Bradford and Mr. Ritter have constructed the following table (12) and diagram (F), in which there are "graphical corrections" and "adjustments" not ventured upon in the preceding exhibits of this report. The results, however, warrant the statement that Governor's Island tide and Willets Point tide can each of them be so decomposed that a diurnal element common to both is discovered, and that this element appears at the same time at Governor's Island that it does at Willets Point.

TABLE 12.—*Decomposition of tides.*

[Computed by G. Bradford and Homer P. Ritter.]

Date.	Time.	Governor's Island.			Willets Point.		
		Diurnal wave.	Semi-diurnal wave.	Observed gauge reading.	Diurnal wave.	Semi-diurnal wave.	Observed gauge reading.
1886.	*h. m.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Oct. 5	20 00	+0.12	3.06	3.18	+0.12	6.08	6.20
	30	+0.08	2.95	3.03	+0.08	5.41	5.49
	21 00	0.00	2.88	2.88	0.00	4.58	4.58
	30	−0.05	2.89	2.84	−0.05	3.75	3.70
	22 00	−0.10	3.15	3.05	−0.10	3.00	2.90
	30	−0.13	3.50	3.37	−0.13	2.43	2.30
	23 00	−0.16	3.88	3.72	−0.16	2.06	1.90
	30	−0.18	4.29	4.11	−0.18	1.91	1.73
Oct. 6	0 00	−0.20	4.66	4.46	−0.20	1.81	1.61
	30	−0.20	5.22	5.02	−0.20	1.68	1.46
	1 00	−0.20	5.63	5.43	−0.20	1.67	1.45
	30	−0.20	6.06	5.86	−0.20	1.85	1.65
	2 00	−0.21	6.26	6.06	−0.21	2.45	2.24
	30	−0.21	6.26	6.05	−0.21	3.31	3.10
	3 00	−0.20	6.22	6.01	−0.20	4.34	4.14
	30	−0.20	6.13	5.93	−0.20	5.40	5.20
	4 00	−0.20	5.86	5.66	−0.20	6.28	6.08
	30	−0.19	5.52	5.33	−0.19	6.89	6.70
	5 00	−0.18	5.25	5.07	−0.18	7.18	7.00
	30	−0.17	4.99	4.82	−0.17	7.34	7.17
	6 00	−0.16	4.73	4.57	−0.16	7.43	7.25
	30	−0.14	4.37	4.23	−0.14	7.48	7.32
	7 00	−0.12	4.02	3.90	−0.12	7.48	7.35
	30	−0.10	3.70	3.58	−0.10	7.38	7.28
	8 00	−0.06	3.40	3.34	−0.06	6.97	6.89
	30	−0.00	3.20	3.20	0.00	6.23	6.23
	9 00	+0.04	2.99	3.02	+0.04	5.36	5.40
	30	+0.08	2.90	3.01	+0.08	4.43	4.51
	10 00	+0.12	3.03	3.18	+0.12	3.48	3.60
	30	+0.18	3.28	3.46	+0.18	2.74	2.92
	11 00	+0.22	3.68	3.90	+0.22	2.19	2.40
	30	+0.24	4.14	4.38	+0.24	1.94	2.18

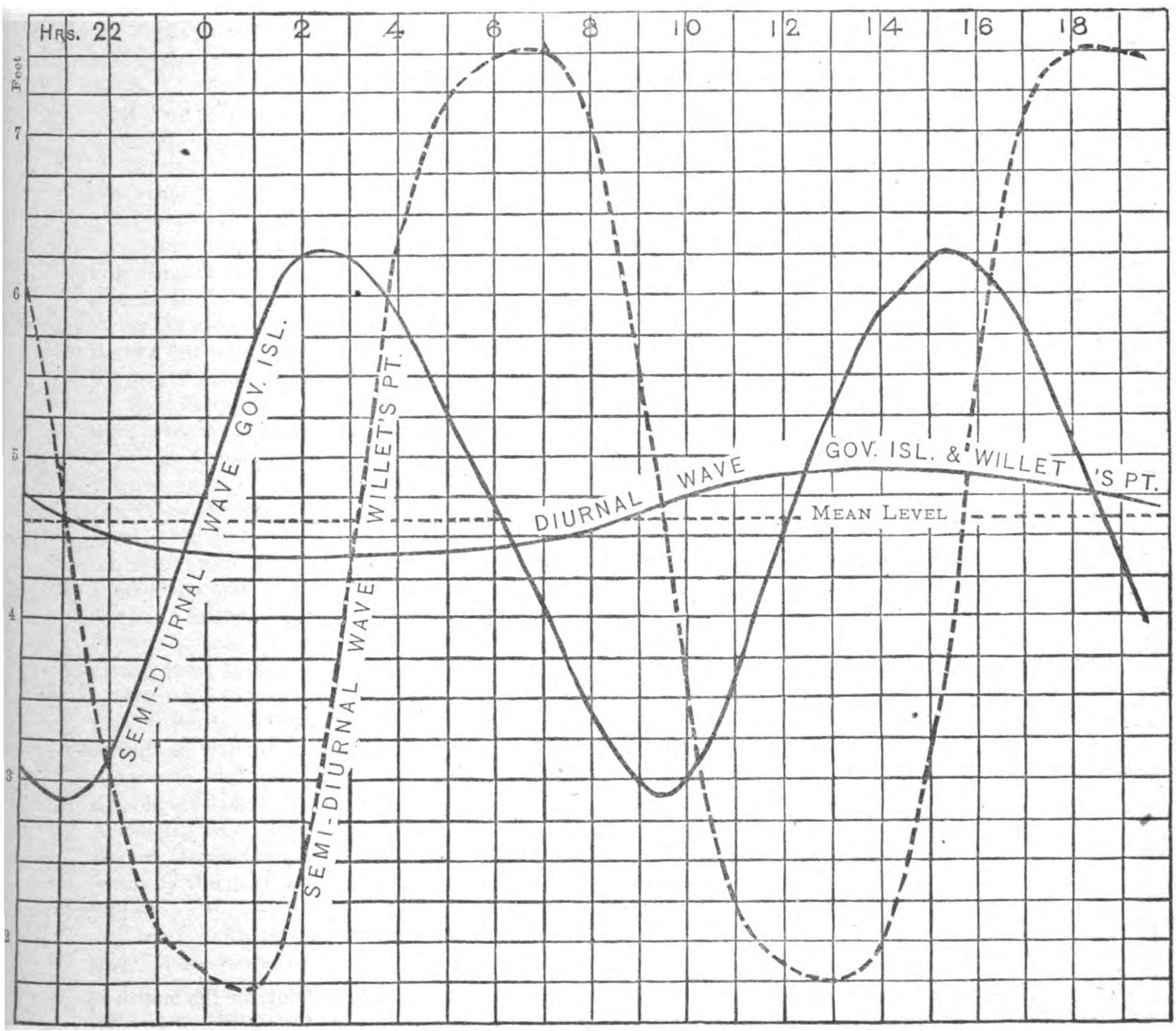
TABLE 12.—*Decomposition of tides*—Continued.

Date.	Time.	Governor's Island.			Willets Point.		
		Diurnal wave.	Semi-diurnal wave.	Observed gauge reading.	Diurnal wave.	Semi-diurnal wave.	Observed gauge reading.
1886.	*h. m.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Oct. 6	12 00	+0.26	4.57	4.83	+0.26	1.86	2.12
	30	+0.28	5.02	5.30	+0.28	1.83	2.10
	13 00	+0.30	5.32	5.62	+0.30	1.72	2.02
	30	+0.30	5.61	5.91	+0.30	1.80	2.10
	14 00	+0.30	5.81	6.11	+0.30	2.02	2.32
	30	+0.30	6.00	6.28	+0.30	2.50	2.80
	15 00	+0.30	6.18	6.45	+0.30	3.20	3.50
	30	+0.29	6.25	6.51	+0.29	4.18	4.50
	16 00	+0.28	6.17	6.45	+0.28	5.32	5.60
	30	+0.26	6.07	6.33	+0.26	6.29	6.55
	17 00	+0.22	5.77	5.99	+0.22	7.05	7.29
	30	+0.23	5.46	5.69	+0.23	7.37	7.60
	18 00	+0.20	5.00	5.20	+0.20	7.44	7.64
	30	+0.16	4.75	4.90	+0.16	7.51	7.67
	19 00	+0.14	4.31	4.45	+0.14	7.44	7.60
	30	+0.12	3.96	4.08	+0.12	7.48	7.57

DIAG. F.

DECOMPOSITION OF TIDES.

No. 39



The diurnal oscillation, being small and of long duration, requires but little action, and betrays therefore little *re*-action. It is not appreciably changed by its journey through Long Island Sound. The same is true of other oscillations of great amplitude, as, for instance, the half-monthly fluxes. In my study of the Bay of Fundy tide (see Appendix No. 10, Annual Report Coast and Geodetic Survey, 1879) I found that the semi-diurnal tide *reversed* as it passed from the Atlantic into the Gulf of Maine, but the diurnal tide did not.

In the following table Mr. Bradford has compared mean levels at Governor's Island and Willets Point:

Table 13.—*Comparison of mean levels, Governor's Island and Willets Point.*

Date.	Mean level. Governor's Island.	Mean level. Willets Point.	Difference.	Moon's declination at noon.	Moon's upper transit.
1886.	*Feet.*	*Feet.*	*Feet.*	°	*Hours.*
Oct. 5	4.34	4.39	—0.05	S. 18	19
6	4.63	4.67	—0.04	S. 17	19
7	4.95	4.99	—0.04	S. 15	20
8	4.71	4.77	—0.06	S. 12	21
9	4.25	4.15	+0.10	S. 9	22
10	4.51	4.45	+0.06	S. 5	22
11	4.56	4.51	+0.05	S. 2	23
12	4.44	4.35	+0.09	N. 2	24
13	4.67	4.80	—0.13	N. 6	1
14	5.23	5.00	+0.23	N. 10	1
15	4.46	4.30	+0.16	N. 13	2
16	3.52	3.51	+0.01	N. 16	3
17	4.24	4.10	+0.14	N. 18	4
18	4.04	4.12	—0.08	N. 19	5
19	4.40	4.39	+0.01	N. 19	6
20	4.13	4.17	—0.04	N. 18	7
21	3.75	3.89	—0.14	N. 16	8
22	3.93	4.13	—0.20	N. 13	8
23	*3.94	*4.32	*—0.38	N. 9	9
24	4.63	4.82	—0.19	N. 4	10
25	4.49	4.46	+0.03	N. 0	11
26	4.45	4.46	—0.01	S. 5	12
27	*4.89	*5.34	*—0.45	S. 10	12
28	4.91	4.73	+0.18	S. 13	13
29	4.96	4.93	+0.03	S. 16	14
Mean.	4.44	4.44	0.00		

*Rejected in means.

This comparison of the mean levels for Governor's Island and Willets Point, for the month of October, furnishes but little positive information. At zero declination of the moon and at maximum declination (north or south) the tides from the Sound and those from the Sandy Hook entrance rise and fall from the same absolute plane; but at the time of rapid change of declination especially on the increase, our computations furnish discordant results. There is no regular half monthly flux through New York Harbor recurring with similar declinations of the moon; but there is evidently an irregular flux—often of many days' duration—dependent upon the course of the wind. As might be expected, northeasterly winds blowing along the axis of Long Island

Sound are the most potent in disturbing the equilibrium at the Hell Gate entrance, the shallow waters of the Sound being heaped up and crowded up to leeward very considerably. In our single-month's comparison we had no stormy weather, but a moderate northeasterly wind raised the mean level of the western end of Long Island Sound nearly a half foot above the harbor on one occasion. In a former survey of Hell Gate I estimated the rise of a great northeast storm at over 6 feet, the greatest rise on the open coast due to storms being 4 feet. The highest estimate that I have heard for the rise at Hell Gate is 8 feet, which occurred during an easterly gale. To this effect of easterly winds there is no counterpoise. Westerly winds cannot have much effect in the short and narrow reaches approaching the Gate, and over a supposititious dam at Hallet's Point we behold the wind waters often welling over to the westward but perhaps never to the eastward.

Until we can keep gauges in operation at both entrances to New York—*i. e.*, at Sandy Hook, and Willets Point—for a year of good observations, we cannot determine any half monthly variations of mean level, nor can we measure the effects of winds. It is possible that without consideration of the winds we may be reckoning without our host in the physical scheme of New York Harbor.

To return to the salient point of this paper, viz, the determination of the direction of the net discharge by observing the difference in the elevation of the "lunes" at the meeting of the tides, I desire to call attention to other applications of this key:

Between the southeastern angle of the coast of Massachusetts and Cape Sable, Nova Scotia, a *node* occurs in the semi-diurnal tide, with profiles on either side closely resembling those on the two sides of Hell Gate.* In this case the currents at the entrance to the Gulf of Maine are not flowing under the direct action of gravity in the sense that we should speak of the flood and ebb of the East River; but when we leave the open sea and turn to the Barrington Passage at Cape Sable or the Vineyard Sound of Massachusetts, we entertain something like the same problem that we have in the East River, and a net movement in one direction must be involved. If, for instance, we plot the tidal profiles of Monomoy (or Great Point, Nantucket) with the tidal profile of Menemsha Bight (Gay Head), we discover that the westwardly slope lies at an average *stage* of about 0.25 feet above the average *stage* of the eastwardly slope; and although variations of ratio of perimeter to section hardly count for anything in these broad sounds we must admit, as inevitable, a net movement westward. We actually find from observation that the differences of stage either way from West Chop contradict each other, but that in the adjustment, *slope* replaces *stage*, and in the Narrows between West Chop and Nobska we have a preponderance of westerly slope out of all proportion to the opposing inequalities of duration. I am quite aware that this part of my theme is very obscure in the absence of diagrams, but I have thought it well to record these phenomena, kindred to those of the East River, because the bar at New York is by antithesis placed in the same category of obstructions to which the Monomoy Shoals belong. At New York Bar the net movement is outward towards the ocean, and the shoals are thrust back; but the southern tidal current on the outside of Cape Cod falling at high *stage* is the active agent in sweeping the shore sands down to the mouth of Nantucket Sound where they find a movement westward, *i. e.*, into the Sound. It is a rare case; but the march of the shoals seems to bear out our view of the agencies at work. (See Appendix No. 8, Annual Report of the Coast and Geodetic Survey, 1886, and Appendix A, Annual Report Harbor and Land Commission of Massachusetts, 1886; see also a paper intended for publication in the next Annual Report, entitled "Movements of the Sands at the Entrance to Vineyard Sound.")

In the "Report of the Advisory Council of the Joint Committee of the Massachusetts Legislature" on the proposed Cape Cod Canal, 1860, there is a sketch of mine to be found showing the tides of Barnstable Bay and Buzzard's Bay as simultaneously observed. This sketch resembles closely the one we have given for the Hell Gate interference, and in a similar way predetermines the direction of the net discharge through the canal. In the canal sketch the mean *slope* in either direction is 3.40 feet, and the difference of *stage* (as indicated by the mean difference in the elevations of the "lunes") is 1.42 feet in favor of the westerly tidal current. In other words, the current which will run to the westward from Barnstable Bay to Buzzard's Bay will find 1.42 feet more water than

*See Appendix No. 10, Coast and Geodetic Survey Report, 1879.

its alternative; it will therefore have greater velocity and greater transverse section, and consequently much greater discharge. In this instance, more conspicuously than in the natural canal at New York, this circulation to be induced by the Cape Cod Canal presents a paradox. Here are two seas now on the same mean level, and the tides are only oscillations equally above and below this same mean level, yet *the canal, when opened, will give rise to a resultant flow in one direction tending to disturb the level.*

From similar reasoning one might predict that if a ship-canal without gates could be built from the Bay of Fundy to the Gulf of Saint Lawrence, there would be a net discharge towards the Saint Lawrence. And, similarly, if a free canal be built across the Isthmus of Panama there will be a resultant flow from the Pacific Ocean to the Caribbean Sea.

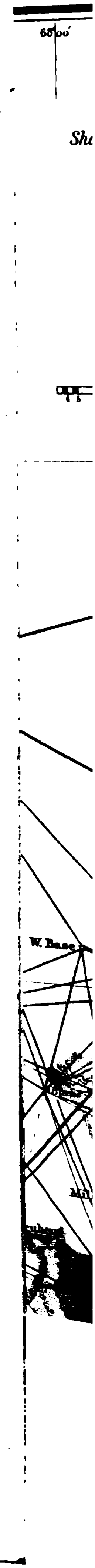
HENRY MITCHELL,
Assistant, U. S. Coast and Geodetic Survey.

MAY 6, 1887.

PROGRESS SKETCHES.

NOTE.—For list of illustrations see page 435.

ILLUSTRATIONS.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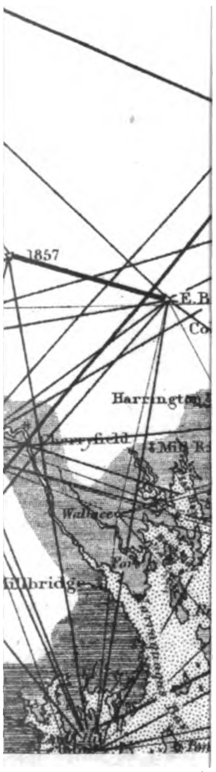

Tennessee

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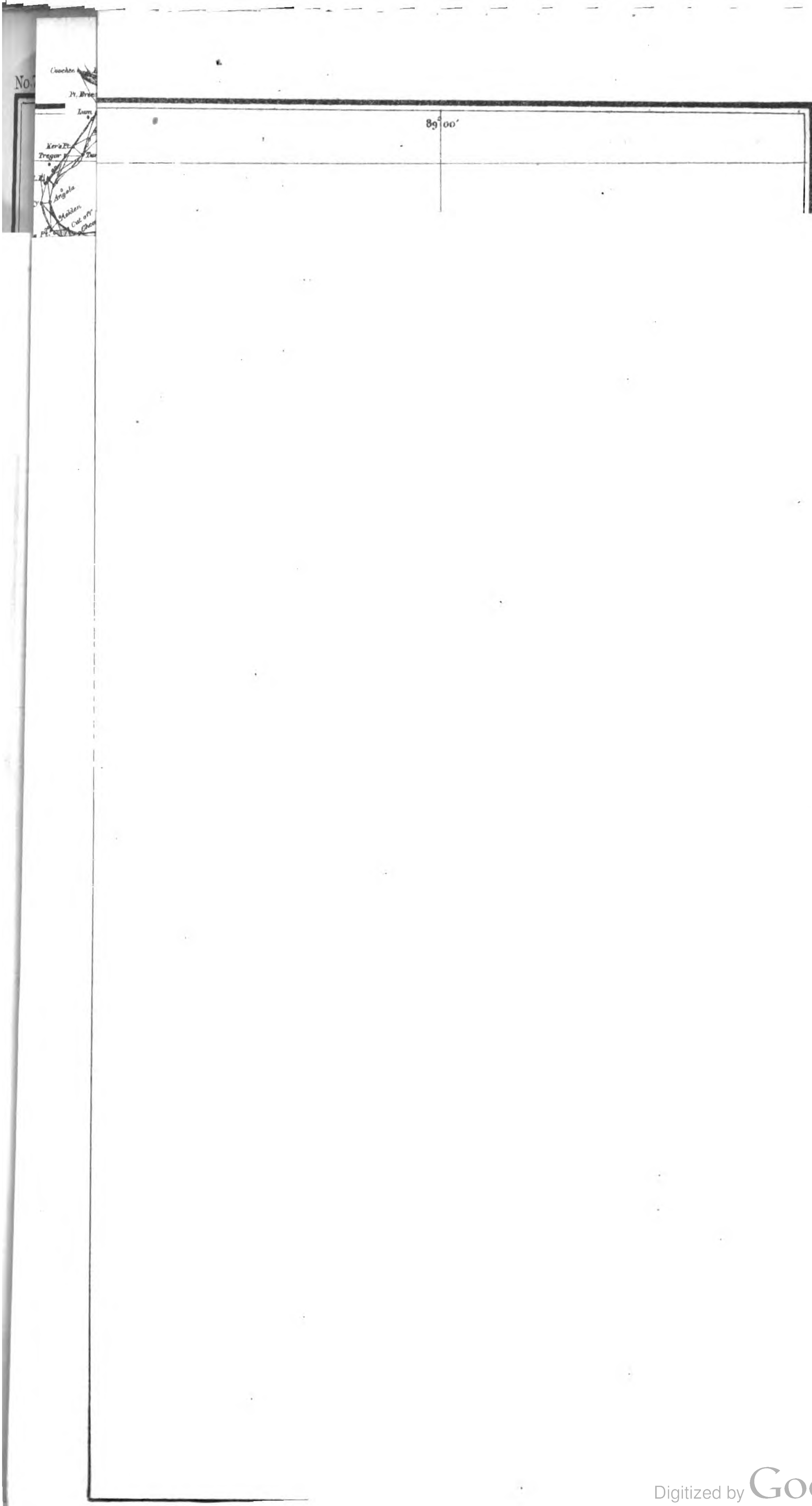
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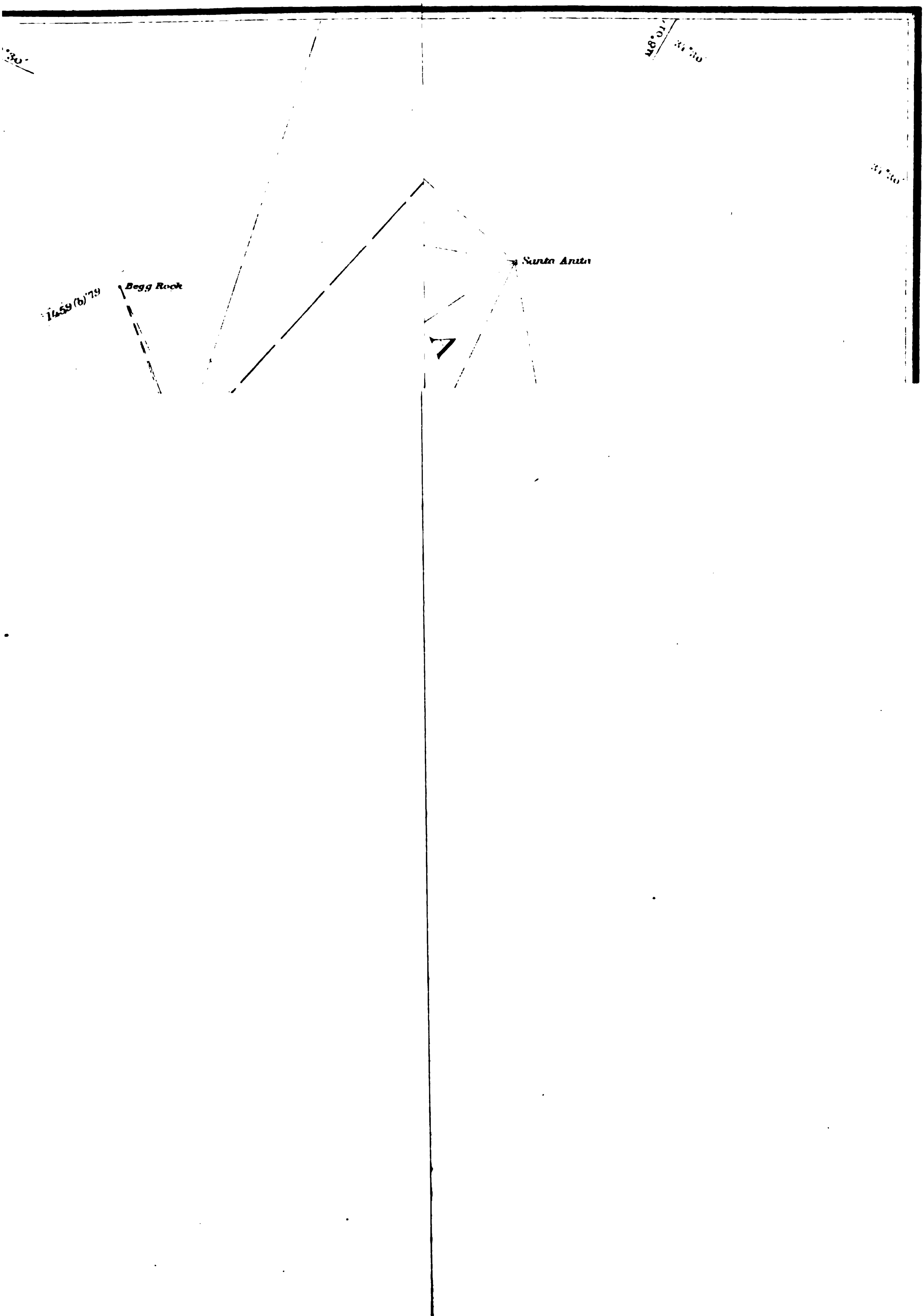

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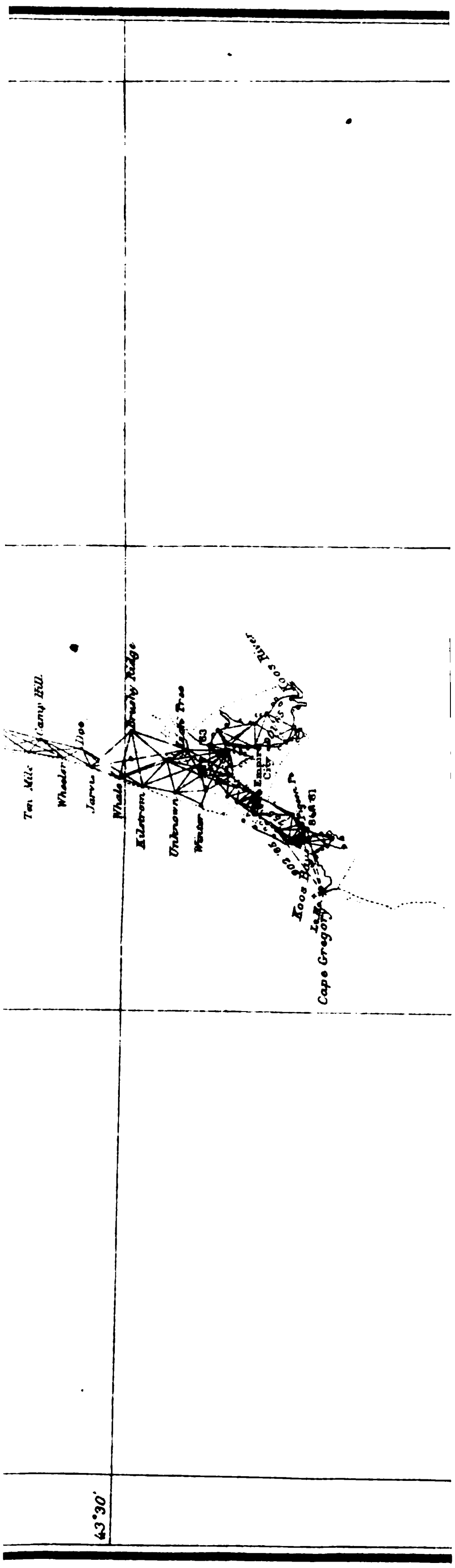
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Kilstrom
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Winter
Koos Bay
Cape Gregory
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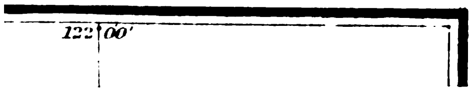
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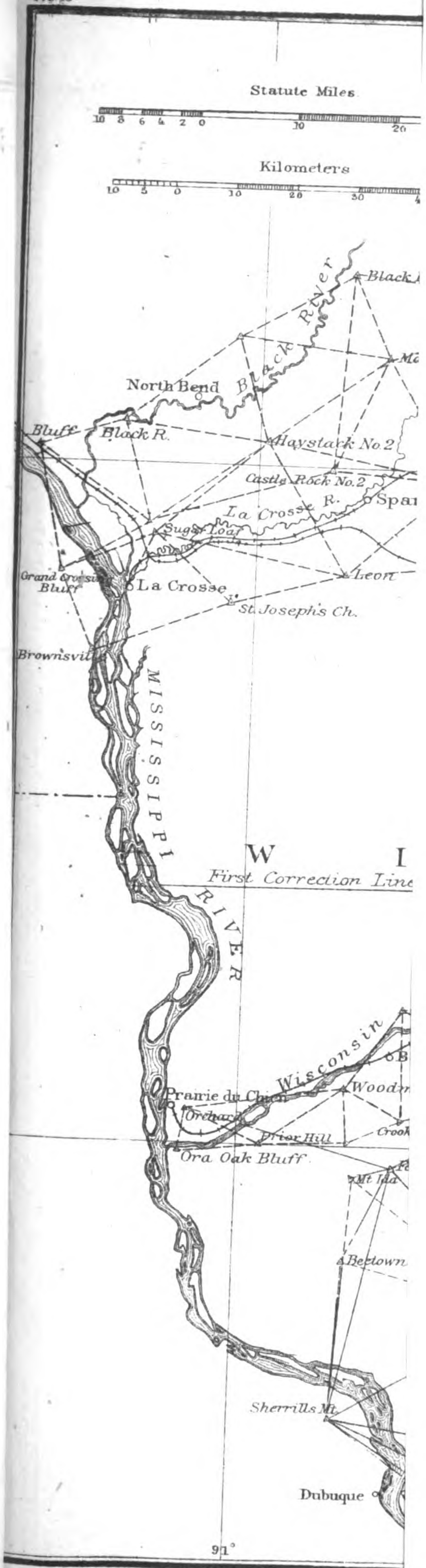
Statute Miles
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Black River
North Bend
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Haystack No. 2
Castle Rock No. 2
La Crosse R.
Sugar Loaf
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St. Joseph's Ch.
MISSISSIPPI RIVER
W I
Wisconsin
Prairie du Chien
Orchard
Prior Hill
Ora Oak Bluff
Mt Ida
Beetown
Sherrills Mt.
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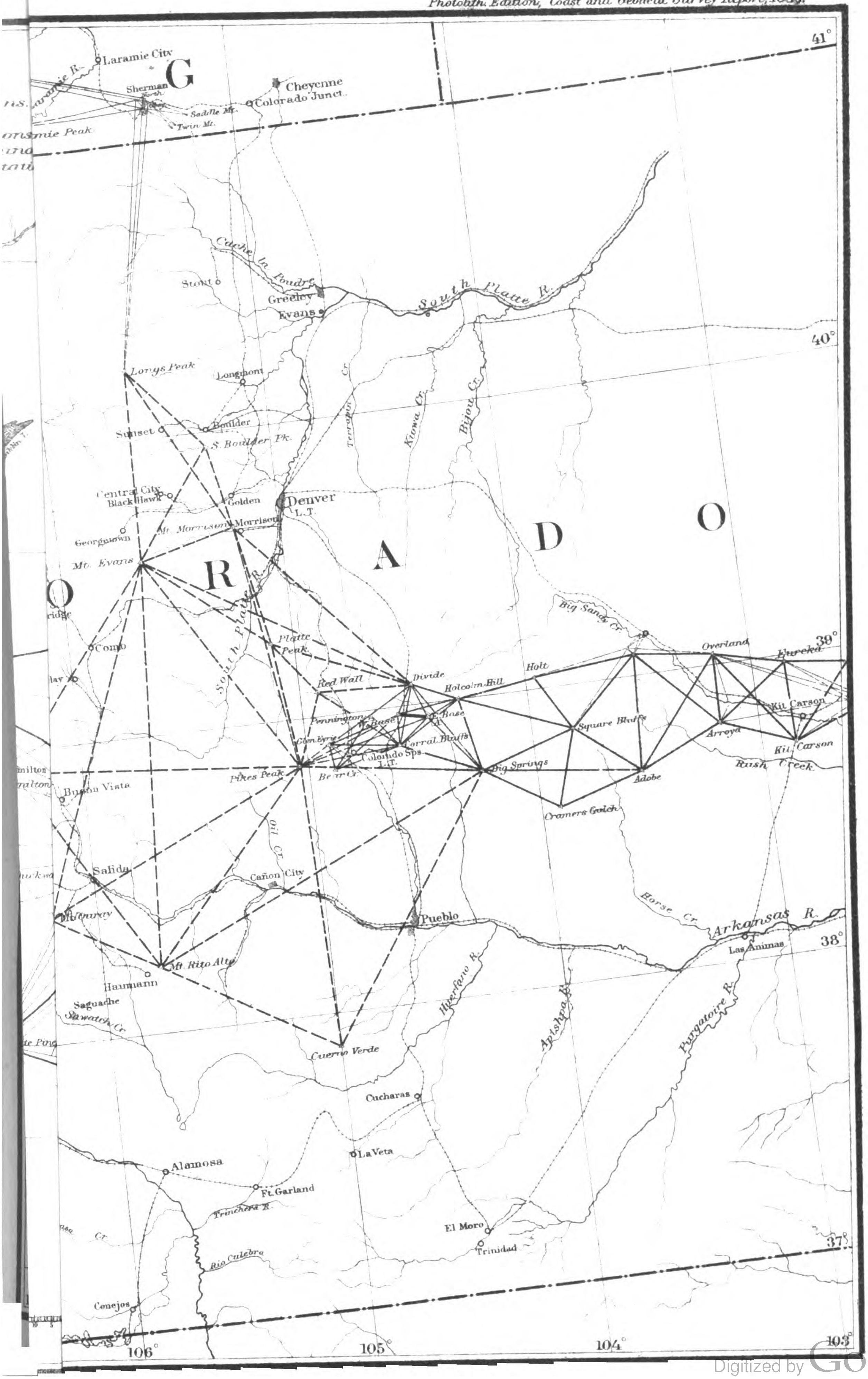
Photolith. Edition, Coast and Geodetic Survey Report, 1883.



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From Observations by Spanish Navigators between 1774 & 1790.